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STUDIES IN THE SOCIAL PSYCHOLOGY OF STRESS

DEPARTMENT OF PSYCHOLOGY

UNIVERSITY OF ILLINOIS

URBANA, ILLINOIS

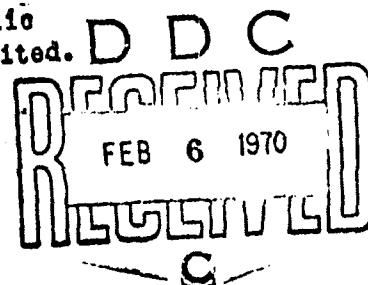
PREDICTION OF CHARACTERISTICS
OF GROUP OUTPUT FROM INDIVIDUAL
PERFORMANCE CHARACTERISTICS

Rosemary H. Lowe
J. E. McGrath

August, 1969

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Research on Social Psychological Factors
in Human Stress. Air Force Office of
Scientific Research Contract AF-1161-67
J. E. McGrath, Principal Investigator

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FORWARD

This research was conducted in conjunction with a program of research on Social and Psychological Factors in Stress (AFOSR Grant AF 1161-66 and AF 1161-67, J. E. McGrath, principal investigator).

It is an attempt to explore certain models for describing how group members combine their resources in accomplishing group tasks.

Other completed studies in the program include:

McGrath, J. E. (Ed.) Social and psychological factors in human stress. New York: Holt, Rinehart & Winston, (in press).

Steiner, I. D. Perceived freedom. In L. Berkowitz (Ed.) Advances in social psychology, Vol. V. New York: Academic Press, 1970.

Steiner, I. D. & Darroch, R. K. Relationship between the quality of counter-attitudinal performance and attitude change. Journal of Personality and Social Psychology, 1961, 4, 312-320.

Stapert, J. C. & McGrath, J. E. Multiple methods in the longitudinal study of small groups under stress. T. R. #AFOSR 69-2059, Department of Psychology, University of Illinois, Urbana, Illinois, August, 1969.

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ABSTRACT

This report is a by-product of a major research program on the social and psychological aspects of stress. Characteristics of the performance of individuals were used to predict the same dimensions of the products they wrote as 4-man groups. The minimum, maximum, and average individuals' scores were correlated with the group's score, for 8 rated dimensions of written products and for time to solution. For all groups in the study, 3 dimensions and time to solution were highly predictable using more than 1 of the basic models; these 3 dimensions were those which best differentiated the 3 types of tasks in the sample. When the task types were separated predictability of group scores with the 3 models varied with task type and dimensions; the minimum individual's score was generally a better predictor of the group scores than was the maximum or average, and this model compared favorably with prediction using multiple linear regression. The concepts pattern of positive and negative correlations between group scores and those of the minimum individual.

CHAPTER I: INTRODUCTION

A. The Problem

One of the early questions addressed by researchers in social psychology concerned the comparison of the performance of individuals with that of groups. As research accumulated, using a variety of "groups," "individuals," and methods of comparing the two, it became clear that the answer to this apparently simple question was much more complex than had originally been assumed.

As illustrated by Lorge, Fox, Davitz, and Brenner (1958) in their review of the literature in this area, laboratory studies have generally been concerned with situations involving learning and/or memory; with judgment, estimation, or decision-making; or with problem-solving tasks. According to a recent summary by Davis (in press), when a group-individual difference occurs in learning situations, groups are more likely than individuals to produce a correct response, and to do so more quickly; they are less likely to make errors. Group superiority in problem-solving is reflected in quality of solution and number of errors, and less frequently in time to solution; however, in terms of man-hours, efficiency may be less for groups than for individuals. In judgment tasks, the group is generally more accurate than an individual; this superiority can often be accounted for by statistical or probabilistic factors rather than by the facilitating effects of interaction.

Besides the wide variety of task situations in the literature, a second complication is recognized by Lorge, et. al., (1958): the "partial confounding...between task and kind of group" (p. 342). That is, a particular type of "group" has generally been used only within studies involving one of the above task situations. Lorge, et. al., summarize the various types of these so-called "groups" with which individuals might be compared:

1. Interacting, face-to-face group, i.e., involving group meeting and discussion:
 - a. with a tradition of working together (traditioned)
 - b. with no tradition of working together (ad hoc)
2. Noninteracting face-to-face group, i.e., involving physical meeting, but no discussion:
 - a. with a sequel appraisal of group opinion (climatized)
 - b. with a sequel appraisal of individual opinion (social climatized)
3. Noninteracting non-face-to-face group, i.e., involving no meeting and no discussion:
 - a. averaging of individuals' performances (statisticized)
 - b. combining of individuals' performances (concocted) (p. 340).

The "individuals" with whom a group's performance is compared vary considerably as well. The average individual may fall short of the average group in quality of output, while the most able man may actually perform better alone than does the best group. In addition, recent appraisals of the literature on social facilitation and inhibition (Davis, in press; Zajonc, 1965, 1966) suggest that the "individual performance" of the same person may vary considerably when he is isolated, in the presence of an audience, or in the presence of other coacting individuals. The direction of this difference seems to depend on the task. In general, Zajonc (1965) suggests that performance of well-learned tasks is facilitated by the presence of others. On the other hand, the acquisition of habits and the performance of

novel or barely-learned tasks seems to be impeded by audiences or coactors except when these coactors provide cues to the performance desired of or by the actor.

A final complexity in attempts to show superiority of either the group or the individual has arisen because the early studies in this area (for example, Gordon, 1923; Knight, 1921) often compared individual performances with some combination of these same individual performances into a "group" performance (the "statisticized" or "concocted" group of Lorge, et. al., 1958). More recently (for example, Shaw, 1932; Taylor, Berry & Block, 1958) the tendency has been to compare individual performances, either separately or combined in various ways, with the output of the same or different individuals when they interact (as in "ad hoc" or "traditioned" groups). The former comparisons frequently illustrated mathematical or statistical principles (Collins & Guetzkow, 1964; Secord & Backman, 1964). More recently, Steiner (1966) has suggested an idea to which this discussion will return: the latter type of comparison allows the experimenter to evaluate various assumptions about group processes, or how individuals combine their resources to produce a group performance. As pointed out by Davis (in press), the early problem of individual versus group superiority has evolved into the more complex question of determining the factors important in group process.

B. Approach of the Present Research

Attempts to investigate the relationships between individual and group performances have, as indicated above, involved various sorts of tasks, and many interpretations of "individual" and "group." The research reported herein represents an attempt to produce generalizable results pertinent to this question.

This study represents the junction of two lines of research in social psychology. The first involves a set of tasks, and criteria for their evaluation, which allow the present research to obtain the same output measures for comparable tasks. This permits comparison of the performances of an individual when he is working alone, and when he is part of a group. The second is the large body of conceptual and empirical work concerned with the prediction of group performance from data on individuals. The following sections will consider in greater detail these two bases for the present investigation.

Tasks and Performance Criteria

Among the conditions which determine whether group effort will be superior to individual work, and which foster various sorts of combinations of individual contributions, one important variable is the type of task or problem presented to the subjects. The relevance of task type to the individual versus group issue is well documented in an integrative summary of this literature by Collins and Guetzkow (1964). As indicated in a theoretical paper by Steiner (1966), the demands of the task are also related to group productivity in that they "determine whether a particular kind of resource. . . is relevant, how much of each kind of resource is needed for optimal performance, and how the various relevant resources must be combined and utilized in order to produce the best possible outcome" (p. 273).

A current program of research (Hackman, 1965a, 1966; Hackman & Jones, 1965; Hackman, Jones & McGrath, 1967; Kent, 1967; and Morris, 1965) provides a task technology which can be used to advantage in the present study. That program began as an attempt to develop a taxonomy of group tasks and a methodology with which the differences among them might be studied. The tasks and performance criteria

developed in this research program have provided a convenient methodology for use in the present investigation into the individual-group performance question. Tasks included in the original Hackman scheme are intellectual, rather than manipulative or motor; there are many potential solutions to each task, but the group is required to construct a single written product. Although the tasks were originally written for performance by groups, they are suitable for presentation to individuals as well.

Through factor analytic methods, a stable set of six dimensions has been developed for the description of products generated in response to these tasks. According to Hackman (1966), these dimensions are:

designed to provide a means whereby the common characteristics of a heterogeneous set of group products (can) be systematically assessed and compared. The dimensions are:

1. Action orientation. The degree to which a product states or implies that a specific or general course of action should be, might be, or will be followed.
2. Length.
3. Originality. The degree to which the ideas and/or mode of presentation of a product are fresh and unusual as opposed to obvious and mundane.
4. Outlook. The degree to which the general point of view or tone of a product can be characterized as "positive" or optimistic as opposed to "negative" or pessimistic.
5. Quality of presentation. Evaluation of the grammatical, rhetorical, and literary qualities of the product.
6. Issue involvement. The degree to which a product takes or implies a particular point of view regarding some goal, event, issue, value, or procedure. (pp. 24-25.)

Judges rate written products on 18 scales, three of which comprise these six product dimensions; these judges are blind to either the task which gave rise to a product, or the group which performed the task. The end result of this procedure is a set of six scores which describes a product, and which allows that product to be compared meaningfully with products generated by other individuals or groups, on the same or

on other tasks and even in other research studies. Since the wide variety and incomparability of the criteria of group performance have been a major impediment to the integration of findings on group productivity to date (Hackman, Jones, & McGrath, 1967) the use of such general or "task-independent" dimensions should permit greater generalizability of experimental results across studies.

Two additional scales have been used in this program of research: the "Creativity" of a product, and the "Adequacy" with which a product fulfills the specific demands of a task. These scales were originally included as an aid to interpreting the nature and size of relationships between task characteristics and the six general product dimensions. They have been retained in the present research because they closely resemble the most frequently used criteria for evaluating the effectiveness of group interaction, as indicated in collections of tasks by Shaw (1963) and Hackman (1965b). Adequacy and Creativity, although rated in a manner similar to the other scales, are "task-dependent" in that the judge must be familiar with a task's requirements before he can evaluate the adequacy and creativity of a response to it.

Tasks within the Hackman collection fall into three types differentiated from one another by process requirements and by their content or "mental materials." According to Hackman (1966), "Each of the three original (task) types is seen as an intersection of a particular kind of process emphasis with a certain class of 'task content'" (p. 68). More specifically, production type tasks emphasize the process of presenting the content of ideas, concepts, or images. In discussion tasks, the evaluation of issues or values takes precedence, while in problem-solving tasks, the group must explain or instruct with reference to specific overt actions. Extensive research and analysis

presented by Hackman (1965a) and replicated by him (1966) and others (Kent, 1967) has indicated that each task type possesses a characteristic profile on the six general dimensions described above. A large body of data exists relating (1) task type and difficulty level to the product dimensions (Hackman, 1966); (2) group sex composition and task type to product dimensions (Kent, 1967); and (3) task type and difficulty level to group interaction process variables (Morris, 1965). However, the performance of individuals on these tasks and the relationships between individual and group products have not yet been intensively studied.

For this reason the present research was designed to extend the Hackman methodology for the study of group performance to the question of the comparison of individual and group performance, and the prediction of the latter from the former. Product dimension scores for an individual's products are considered as his "capabilities" with regard to a particular type of task; they are studied in various combinations with the "capabilities" of other individuals in his group, in an attempt to predict the characteristics of the products generated when these individuals work together on a task quite similar to the ones they completed individually. The existence of standardized tasks of known difficulty level and type thus permits the assessment of individual performance on tasks highly similar to those presented to the group; at the same time the dangers of using the same problem twice (Hoffman, 1965) are avoided.

In essence, the present research follows the strategy suggested by Davis (in press):

Although the use of psychological tests to measure component abilities in task performance is not without merit, the use of task behavior to predict subsequent group task behavior results in even better predictions,

and this latter strategy appears to be the more efficient. . . it should be evident that a knowledge of how individual persons attack a task is insufficient to predict group performance unless allowance is made in the prediction process for the socially induced individual changes. . . and/or the way individual contributions are combined through interaction.

That is, the present research assesses task performances of individuals, and then combines individuals in various ways in an attempt to specify the "socially induced changes" or "way individual contributions are combined" in group performance of similar tasks.

Mathematical Models for the Prediction of Group Output

As social psychologists recognized the importance of task variables in the study of group productivity, they began to apply mathematical models in the prediction of group output from individual performance on varying sorts of tasks. Davis (in press) has reviewed several such approaches to the study of group learning, decision-making, and problem-solving, and suggests that they may be considered as "theoretical baselines" resulting from various hypotheses about the social processes which occur in groups.

Given individual responses or products X , and that social interaction is of the sort Y , then the group product is Z . Real group performance is then compared with the baseline prediction, Z . . . If group performance is greater than Z , then hypotheses about social interaction effects (which predict) less than Z can be disregarded, and attention focused upon obtaining theoretical statements that predict greater than Z . The value of the baseline notion or social process hypothesis lies in the fact that the direct observation of social behavior. . . is often irrationally difficult or even impossible. . . an adequate theory of group performance, can, for some situations, thus be approached by successive approximations more swiftly.

Thus the accuracy of prediction of group performance using a particular model for combining individual outputs can give some information about the tenability of the social process assumptions implied by that model.

A recent paper by Steiner (1966) discusses several models for the prediction of potential group output under different assumptions about the "critical demands" (Roby & Lenzetta, 1958) of the task. The first applies to tasks which require each group member to perform the same activity, such as stuffing envelopes for mailing. When resources are additive, the potential productivity of a group of size n is denoted by $PP_g = n \overline{PP}_i$ where \overline{PP}_i is the mean potential productivity value of all persons in the universe from which members of the group in question have been randomly sampled.

Similar to Steiner's "additive" model is the "independence model" discussed by Thomas and Fink (1961); a comparison of the two reveals that the additive model applies to problems in which group output is measured quantitatively, while the independence model considers the qualitative case of one correct and one or more incorrect answer(s). Using the multinomial theorem to predict the probabilities of various combinations of right and wrong answers in a group, Thomas and Fink assume that solutions of individual members of a group will not differ from the solutions at which they would arrive working alone. According to Thomas and Fink, this model should predict accurately "when the individuals have essentially no influence upon one another, such as when there is no interaction, communication, or interdependence among the group members" (p. 53).

(Thomas and Fink present an additional model to handle the case in which pressures to uniformity do exist within the group, contrary to the assumptions of the independence model. Under the "consensus model," the distribution of members' correct and incorrect answers differs from that which would be found if they worked separately. The consensus model follows the logic of majority or plurality rule:

the group will adopt the solution favored by more members than any other solution. Thus, individuals working together have a greater or lesser probability of being correct than they would working separately, as a function of whether the majority favors the correct solution or an incorrect one.)

A second case considered by Steiner (1966) is that in which the group's potential productivity is set by the competence of its most able member. The "Eureka" task, whose answer is apparent to the entire group when any one member discovers it, may be the most common example of this task type; but any problem which cannot be easily subdivided and which all members can attempt to solve individually, falls in this category also. Steiner refers to this model as "disjunctive, since the group has the ability. . .if at least one of its members possesses the minimum ability required" (p. 227). Less formally, he calls this the "truth wins" situation, for its basic assumption is that the correct solution (if present), or the best answer, will be recognized and will become the group solution.

Two sorts of mathematical models may apply in this case. One approach, taken by Ekman (1955), Lorge and Solomon (1955), and Taylor (1954), considers ability to solve a problem as a dichotomous variable (right-wrong); as developed by Lorge and Solomon (1955), this model uses the binomial expansion to predict the percent of groups which will contain at least one member capable of solving the problem. This model requires that the experimenter know the value of the parameters P and Q , the proportions of individuals in the population who have the ability to solve a problem, or do not have it, respectively. In essence, it predicts that the probability that a group will have at least one member who can succeed will increase as a negatively accelerated

function of group size. The "rational model" of Thomas and Fink (1961) draws the same conclusion on the basis of the multinomial expansion, which considers probabilities of one correct answer and several incorrect alternatives (right, wrong₁, wrong₂, . . . wrong_n) being distributed in various ways within the group.

A further extension of the ideas of the Taylor/Lorge-Solomon/ Ekman approach is that of Davis (Davis, 1961; Davis & Restle, 1963; Restle & Davis, 1962). This line of research presents a model for the prediction of group solution times from individual data, incorporating the "truth wins" notion of the above models for the disjunctive case. According to the "hierarchical model," group members who are unable to solve the problem are "nonfunctional if . . . the solvers suppress non-solvers and form an intellectual hierarchy within the group" (Restle & Davis, 1962, p. 528). Thus, the group's solution time reflects the time required by the group's most capable members.

(On the basis of their research Restle & Davis developed another model for the more accurate prediction of group solution time, on the assumption that group members who cannot solve the problem still consume part of the group's time; they participate in discussion, although they do not contribute to the solution. According to Davis (in press), this "Equalitarian Model. . . was intended to describe the social process rather than serve merely as a baseline to determine the efficiency of effort. In other words, the Equalitarian Model was an attempt to account for the group performance decrement detected as a baseline deviation in a number of similar experiments." The equalitarian model thus forsakes the "truth dominates" idea found in models for Steiner's (1966) disjunctive tasks, and in some ways resembles more closely the additive case for the prediction of solution time.)

Perhaps more appropriate for present consideration (due to the nature of the Hackman tasks and criterion measures) is a second sort of model for the disjunctive task which treats problem-solving competence as an interval-scale variable (Steiner & Rajaratnam, 1961; Steiner, 1966). Assume that this ability is normally distributed in the population, and that groups of size n are randomly assembled from this universe. Members of groups of size $n = 4$ will, on the average, fall at the 80th, 60th, 40th, and 20th percentiles on the scale of ability. Thus, the best member of a four-man group should, over a number of cases, tend to be more competent than 80% of the persons in the population. The larger the size of a group, the higher the percentile at which its best member will probably fall.

Similar to the disjunctive type of task is one in which the ability of the least competent member determines the potential for the group. Steiner (1966) refers to this case as the "conjunctive" task. Discussion groups which require unanimous decisions exemplify the conjunctive type of task: the group's ability to succeed demands that every member be able to succeed. The statistical models appropriate to the disjunctive situation can easily be adapted to the conjunctive case. For example, if problem-solving ability is treated as a continuous variable, under the assumptions of random selection of n group members from a normally distributed population, "the i^{th} most competent members of the groups will have an average level of competence which corresponds to the $\left(\frac{100 (n + 1 - i)}{n + 1} \right)$ th percentile score for the population" (Steiner and Rajaratnam, 1961, p. 297). When potential group productivity depends upon the i^{th} least competent member of the group, this productivity will be a negatively decelerating function of group size.

Early comparisons of group and individual performance made frequent use of tasks falling into Steiner's (1966) fourth category of "compensatory" tasks. If every member of the group makes an independent estimate of some true value, such as the number of beans in a jar or people in an unknown town, the mean of these individual judgments will typically be found to be more accurate than the majority of individual judgments. The larger the number of people estimating this value, the more accurate the mean of their judgments will tend to be, with the reservation that judges be unbiased, or that biases be normally distributed within the population from which the judges are randomly sampled.

Under these conditions, random error and/or biases in both directions will tend to "compensate" for one another and cancel out, so that the average value will tend to approach the correct value. The standard error of the sample mean will give an indication of the degree of accuracy to be expected from groups of various sizes:

$$\sigma_M = \frac{\sigma_x}{\sqrt{N}} ; \text{ where } N \text{ denotes group size, and } \sigma_x \text{ is the standard deviation of individual judgments for the entire population of persons.}$$

Finally, Steiner presents models applicable to tasks in which one person performs only part of the entire task; the remaining members apply their different resources to other subtasks. In such "complementary" tasks, no one individual can complete the problem alone; the various abilities of different group members "complement" one another and permit the entire group to succeed. Models are presented for two distinct cases: (1) the case in which group members hold no resources in common (unshared resources), and (2) that in which each additional member brings to the group some shared resources, but also some unique capabilities (partially shared resources).

In a similar vein, the Lorge and Solomon (1955) treatment of multi-stage problems in their "Model B" uses the "truth wins" notion of the disjunctive task and the binomial expansion to predict the probability of group success even though no single member may be able to solve all stages. Thus, Steiner's (1966) complementary tasks may include multi-stage disjunctive tasks, on which the group will succeed if it contains at least one member who can solve each stage.

Although these models seem intuitively to apply to the majority of "realistic" problems used in small-group research, their application requires that the experimenter know before a problem is solved the specific abilities, items of information, or talents which will be necessary for its solution. When the problem has a number of possible solutions, each requiring a different complex of resources, (as do the tasks utilized in the present research), this knowledge may be quite difficult to obtain until after the problem is solved.

The Steiner (1966) models, as originally presented, concern the problem-solving ability of individuals as related to ability of groups of varying sizes to compose a product of high quality. Each model is designed for a distinct type of task whose solution apparently demands a different combination of these individual problem-solving abilities. A direct test of the models, then, would require that a battery of tasks be written to fit the psychological characteristics described in Steiner's presentation, that groups of several sizes be used, and that quality or correctness of task solution be the dependent variable of interest. Although such a direct test of the models is important and probably quite a feasible undertaking, this is not the main purpose of the present investigation.

Rather, this research focuses on (1) groups of $n = 4$, compared with "groups" of $n = 1$, and (2) the predictability of several charac-

teristics of group products, including quality (or "adequacy"), from the same measures taken on individuals' output. Most of the tasks written by Hackman and Morris appear to fit Steiner's "complementary model;" thus, it would not be surprising if the additive model, for example, were unable to predict group solution quality or adequacy from the same measure on individual products. It is quite possible, however, that other general (i.e., not task-dependent) characteristics of a product may combine in ways not specified by the model which seems to fit a particular task best. For example, the quality of presentation of a solution may reflect the grammatical and stylistic ability of the most competent member of a group, while the length of the same product may, on the other hand, approximate an average of the lengths of individual products. For this reason, the present research will evaluate the utility of several general models (averaging, "best man," etc.) for combining individual scores to predict group performance.

Psychological Dimensions

Steiner's (1966) presentation of several of the above models is unique in that he proposes to infer the potential productivity of groups of various sizes. As this implies, Steiner distinguishes between "actual productivity, what the individual or group does in fact accomplish," and "potential productivity, the . . . maximum level of productivity that can occur when an individual or group employs its fund of resources to meet the task demands of a work situation" (p. 274). Two factors are seen to account for the difference between actual and potential productivity: losses due to nonoptimal motivation, and losses due to faulty coordination. Thus,

$$\text{Actual productivity} = \text{Potential productivity} - \text{motivation losses} - \text{coordination losses.}$$

To reiterate, these models are designed to predict potential productivity; however, according to Steiner, "No attempt is made to provide a complete or systematic treatment of coordination and motivation losses" (p. 275). Perhaps because of this lack of specification of the means for assessing the losses due to poor coordination or motivation, this aspect of the Steiner presentation has not yet, to the knowledge of this writer, been empirically investigated. The present research will thus direct itself to relating potential group output (as predicted by various sorts of combining models) to the performance actually observed, while exploring how the concepts of motivation and coordination relate to these models.

This research has followed Zajonc's (1966) argument that motivation involves physiological activation or arousal. Thus, for present purposes, the "motivation" of a group or individual will be indexed by various measures of overt activity level.

A group is considered "coordinated" when the efforts of individual members are smoothly and economically integrated in the performance of a task, when interference among members is at a minimum. Although coordination in this sense cannot be defined on a single individual, an analogous concept is his efficiency in task performance. Such a conceptualization of "coordination" is maintained in the present research.

Summary of the Present Research

In conclusion, the research reported herein explores the following questions:

1. The predictability of group output characteristics from data on individual task performance, considering both

those dimensions which are independent of the specific task (and thus generalizable to a wide range of tasks), and the more frequently used task-dependent criteria of adequacy and creativity.

2. The utility of several general models for this prediction, considering each criterion dimension separately.
3. The applicability of the model,
$$\text{Actual productivity} = \text{Potential productivity} \pm \text{Motivation} \pm \text{Coordination},$$
including a consideration of the "meaning" of motivation and coordination, using multiple measurements of each.
4. The relationship between individual product characteristics and those of group products.
5. The replicability of relevant previous results concerning task type differences in product dimensions, using standard tasks and instruments.

CHAPTER II: PROCEDURES

A. Subjects

The Ss were 328 male undergraduates enrolled in the introductory psychology course at the University of Illinois. They participated in the experiment as part of their required work in the course during the fall semester, 1968.

Two hundred and eighty-eight of these Ss composed 72 four-man groups in the main portion of the experiment, and the remaining 40 Ss were assigned to a Control condition, hereafter referred to as the "I-I Series."

B. Design

The main portion of the experimental design included two condition sequences (group-individual and individual-group) and three task types (production, discussion, and problem-solving). Within each combination of task type and condition sequence, four task orders were used. The experiment included three replications in each condition sequence-task type-task order cell.

The I-I series included one condition (individual-individual) and one task type (problem-solving), with four task orders. The overall design is presented in Figure 1.

Production Tasks	Group-Individual Sequence	3 groups	3 groups	3 groups	3 groups
	Individual-Group Sequence	3 groups	3 groups	3 groups	3 groups
Discussion Tasks	Group-Individual Sequence	3 groups	3 groups	3 groups	3 groups
	Individual-Group Sequence	3 groups	3 groups	3 groups	3 groups
Problem-Solving Tasks	Group-Individual Sequence	3 groups	3 groups	3 groups	3 groups
	Individual-Group Sequence	3 groups	3 groups	3 groups	3 groups
	Individual-Individual Sequence	11 <u>Ss</u>	11 <u>Ss</u>	8 <u>Ss</u>	10 <u>Ss</u>
		ABCD	BCDA	CDAB	DABC
		Task Order			

Figure 1. Design of the Study.

Conditions and Sequences

The experimental design included two treatment conditions: Individual coacting and Group interacting. During the two-hour experimental session, each S in the main body of the experiment worked individually for one hour, and with three other Ss in a four-man group for a second hour.

One half of the Ss in the main portion of the design participated first individually, then in a group for the second hour. The sequence of conditions was reversed for the other 144 Ss.

Since a main interest of the experiment was the prediction of characteristics of group output from knowledge of individual products, there was also some question about the stability of individual performance. For this reason, 40 Ss were assigned to a Control condition in which they worked for two hours in the Individual treatment. Because of the comparatively small number of Ss in this condition, all Ss completed tasks of the same type. Order of specific tasks was varied as it was within the larger experimental design.

Tasks

The experiment made use of twelve tasks taken from a pool of standard tasks developed by Hackman (1966) for use in small-group research. The tasks are intellectual rather than manipulative, and require a written product; they are suitable for either individuals or groups. According to Hackman, the tasks are of three types: "production tasks. . .involving the presentation of ideas or images; discussion tasks involve evaluation of issues; and problem-solving tasks involve instruction with respect to some overt actions" (1966, p. 70). Past research (Hackman, 1965a, 1966; Hackman & Jones, 1965) has shown that products of each task type show a characteristic profile on six dimensions

developed for the measurement and comparison of written products.

From the 108 tasks in the Hackman pool, four tasks of each type were selected for use in this study. Within each task type, the four tasks were chosen which best represented the profile characteristic of that task type, as determined by the multiple discriminant analysis performed by Hackman (1966). The difficulty level of the tasks, as described by Hackman, varied within each task type, but the three types were comparable in range of difficulty and average difficulty level. The tasks and questionnaires used in the present research are presented in the Appendix.

C. Experimental Arrangements

Experimenters

The magnitude of this study required the use of several Es, each trained in administering Individual and Group experimental conditions. Es included several male and female graduate students and three male undergraduate research assistants. Within scheduling limitations, male and female Es were balanced across both conditions and all three task types. To avoid confounding possible experimenter effects with condition effects, no experimenter administered both conditions to the same group.

Administration

The typical experimental session was two hours in length and involved four groups of four male Ss each. Ss were met at the experimental room by one of the Es, who introduced himself and assigned Ss to groups. The E explained that they were participating in a study of group versus individual problem-solving, after which the two four-man groups assigned to the group-individual (G-I) sequence were escorted

to smaller experimental rooms by two other Es for the first hour of the session. The two groups assigned to the individual-group (I-G) sequence remained in the original experimental room for the first hour.

Occasionally S absences prevented the completion of four four-man groups. Any group containing less than four men was assigned to the Control condition, and worked two hours in the Individual treatment. Like the four-man groups in the main part of the experiment, these Ss generally moved to another experimental room for the second hour of work, and were directed by a different E during the first and second hours.

Individual Condition: The four men in a group sat at three sides of a long table, with the fourth side facing the E who was thus able to observe their activity during the hour. Each man was assigned a letter (A,B,C,D) for purposes of identification, and this letter appeared in front of him on a small place-card.

Each man was given a five-minute warm-up consisting of three tasks to be read and rated on interest, familiarity, difficulty, and preference. These tasks were selected from the Hackman task pool, and were not used again during this experiment.

At the end of the five minutes, or when all Ss had completed the warm-up, each man filled out a questionnaire on which he rated himself and each other man in his group on seven-point scales designed to assess general activity and task activity. In addition, he indicated his confidence in these judgments on another seven-point scale. This questionnaire was identical to that used after each experimental task in this condition, and was inserted after the warm-up in order to alert Ss to the activity of the other men in their groups.

Ss then began the first of two experimental tasks. Each S received a task card and two sheets of paper on which to record his written product. Ss were told they would have 15 minutes in which to complete the task, and were given a signal to begin working individually on it.

During the 15 minutes allotted for the first task, the E noted the behavior of each S in a group at one-minute intervals. If a man finished the task before the 15 minutes had elapsed, he signalled the E, who recorded his completion time. No one was allowed to proceed to the next task in the experiment until all Ss had finished, or until the end of the 15-minute period.

At this point each man completed another copy of the questionnaire which had been given after the warm-up, on which he evaluated the behavior of himself and the other men in his group. The E also rated each man in each group on general activity and task performance. The Ss then proceeded to the second experimental task, the behavior observation during the task and post-task ratings by E and by Ss were repeated for this task, and completed the activity in the Individual session.

Group condition: Having been escorted to a smaller experimental room by an E, the four men in a group took their seats around three sides of a small table, with the fourth side facing the E who was seated behind another table at the other end of the room. On the wall behind the men were small signs lettered A, B, C, and D; each man sat in front of the letter which identified him. (He was assigned the same letter during both hours of the experiment.)

The E told the group that they would solve two tasks as a group during the hour, and that from time to time he would photograph them as a record of their activity. They were also told that the session would

be tape-recorded.

The men were then given one copy of a warm-up task like that used in the Individual condition, but containing different sample tasks. They were told that they would have five minutes in which to complete this warm-up, and that it should be done as a group effort. It was explained that this task was included in order that they might become accustomed to the instrumentation in the room, and to working as a group. Finally, they were asked to signal the E if they completed the warm-up to their satisfaction before the end of the allotted five minutes.

At the end of the warm-up, each S completed a questionnaire on which he rated the general behavior and task performance of himself and each other man in his group on seven-point scales. He also rated the group as a whole on similar scales designed to measure the group's coordination on the task and its activity-motivation. (During some sessions, this questionnaire was omitted after the warm-up task only if time was short. It was felt that this was the least disruptive way of shortening the Group session, since Ss felt less hesitant in the Group condition than in the Individual session to evaluate their fellow group-members without prior knowledge that they would be asked to do so.)

Next the group proceeded to the first experimental task. Members were given one task card and one task sheet upon which to write their product. Four pens were available so that any one of the men could write. Ss were told they would have 15 minutes in which to complete the task, and they should signal the E if they finished the task before the allotted time. The E then turned on the tape recorder, resumed his seat, and signalled the group to begin. While the task was

in progress, the E photographed the group three times during the first five seconds of each minute. A Hunter timer signalled the beginning and the end of this five-second span. The E also recorded which man or men had spoken during the five-second interval.

At the end of 15 minutes, or when the Ss indicated that they had completed the task, each man filled out another copy of the questionnaire given after the warm-up. On a similar questionnaire the E made the same judgments about the general activity and task performance of each S and of the group as a whole; he also indicated which man or men had taken the roles of leader, scribe, inactive member and active member.

The group was then given a second experimental task. Procedures for tape recording, photographing, and rating remained the same as for the first 15-minute task.

Both conditions: At the end of the first hour the groups exchanged rooms and conditions, so that those who had worked individually now worked as a group, and vice versa. At the end of the second hour, each S completed an additional questionnaire on which he indicated which condition he preferred, and which of his fellow group members, if any, he would prefer to work with were he to perform similar tasks in the future. Ss were then told in greater detail the aims of the study, and were given an opportunity to ask questions about the experiment.

I-I Series: In this condition, procedures were identical to those for the Ss in the Individual condition. At the end of the first hour, I-I Series Ss moved to another experimental room and the same procedures were repeated by a second E. As indicated above, all I-I Series Ss performed the same four problem-solving tasks; four task orders were rotated across the groups in this condition.

CHAPTER III: CODING OF DATA

A. Group Product Measures

The data of main interest in this experiment are the 720 products generated by the 72 groups under Group and Individual conditions. Each group provided two written products, and each of its four members completed two more products individually. In addition, each of the 40 Ss in the I-I Series contributed four products to the total pool of 880.

Following Hackman (1966), two types of measures were used to describe characteristics of these products:

- (a) general dimensions on which a product can be judged without knowledge of the requirements of the task to which the product is a response; and
- (b) task-dependent dimensions, for which the judge must be familiar with the actual requirements of the task.

Six general dimensions were derived by Hackman (1965) as a systematic means of measuring and comparing characteristics of written group products from numerous and varied tasks. These dimensions are Action Orientation, Length, Originality, Outlook (positive/negative), Quality of Presentation, and Issue Involvement. The development of these dimensions and the three scales which define each of them are described in detail by Hackman and Jones (1965) and by Hackman (1966).

Two task-dependent dimensions, Adequacy and Creativity, were also used by Hackman (1966) to characterize group products. Although Hackman's data indicate that these two scales relate less strongly to task type than do the six general dimensions, they were included in the present analysis since they resemble the criteria on which products of group interaction are generally evaluated (Hoffman, 1965).

Rating of Products

In preparation for product rating each hand-written product was first typed onto a standard product rating sheet to eliminate any possible biases due to handwriting. The typist was instructed to make three duplicate copies of each product, and to copy the product exactly without making any corrections in spelling, punctuation, or grammar.

The 720 products from the main body of the design were divided into three sets of 240 products each, arbitrarily labelled product sets J, K, and L. This division resulted in product sets small enough to be rated in one 2½ to 4-hour session, yet as few product sets as possible, so that changes in the raters' frames of reference between product sets might be minimized.

The three product sets were composed by randomly selecting for the first set, products from one group in each cell of the design; a cell contained three replications of a task order by condition sequence by task type combination. (See figure 1.) Thus, individual and group products from one replication appeared in product set J, while products from the other two replications appeared in sets K and L. Each of the three product sets contained both individual and group products, from three task types, two condition sequences, and four task orders. All 160 individual products generated by js in the I-I series were included in a fourth product set.

Using the carbon copies of each task, each product set was then divided into three identical sets, for example, J_1 , J_2 , and J_3 . Since ratings were recorded directly on the product rating sheets, this procedure permitted three judges to rate each product on a given scale without discovering the rating given that product by another judge.

General Dimensions

A total of 15 undergraduate judges was used in the entire rating procedure, with three judges rating each scale. With few exceptions, a judge rated all product sets on any scale for which he was trained. No judge rated more than one scale within a dimension, to avoid spurious inflation of existing correlations among scales within a dimension. To minimize any differences in rating which might be due to sex of the judge, no more than two raters of the same sex were assigned to any one scale.

For the general dimensions, the rating procedure followed the general method devised by Hackman and Jones (1965) and used by Hackman (1966). The training procedure consisted of a careful reading of a two or three paragraph description of the meaning of the scale, after which the rater sorted a series of 13 sample products on that scale. His sort was then compared with a criterion sort prepared by Hackman at the time the original scale descriptions were written. Any discrepancies between the rater's sort and the criterion values were resolved by a discussion with the trainer concerning the interpretation of the scale. Occasionally, disagreements of two categories (on a seven-point scale) were tolerated, when it was determined that they resulted from an actual difference in judgment rather than from a misinterpretation of the meaning of the scale. At each rating session the judge repeated the practice sort

and compared his sort with the criterion to recall the necessary frame of reference.

The actual sorting procedure involved separation of the products in a set into three categories of "high," "medium, neutral, or conflicting evidence," and "low" with respect to the scale in question. The two extreme piles were then sorted into two subcategories each, and the middle group was divided into three subcategories. This procedure resulted in seven categories, which were then reviewed to be certain that differences actually existed between categories five and six, and between two and three.

Although the task and rating methodology in this research followed that reported by Hackman (1966), some changes were made:

1. Since his 1966 publication, Hackman has simplified his original sorting procedure to the form described above. He indicates (personal communication) that results are comparable to those obtained with the earlier, somewhat more complex procedure. The earlier sorting procedure is described in Hackman and Jonas (1965).

2. According to Hackman (personal communication), three scales seem to be sufficient to define each of the six general dimensions, although four scales were used in the original research.

3. Only one rater was assigned to the "operational" scale, "Number of Words," as the small increase in accuracy which might have been gained by the addition of two more raters was not expected to justify the additional time this rating would have required.

4. Although five judges were utilized in earlier research, Hackman (personal communication) has indicated that three judgments provide sufficient stability for further analyses.

Task-dependant Dimensions

The rating process for Adequacy and Creativity was revised somewhat from the original Hackman procedure. A total of 11 judges was used, with three judges rating each product set. Judges included the Es, who already were familiar with requirements of the various tasks, and six undergraduate judges who had rated the general dimensions.

Before rating a product set on Adequacy or Creativity, a judge read through a one-page description of the meaning of the scale, and one copy of all tasks included in the product set he was to rate. He discussed the scale and the rating procedure with a trainer before beginning the rating.

The actual sorting procedure was like that used with the general dimensions, with two exceptions. The product set was separated according to task so that a judge sorted all products from one task into three piles before proceeding to another task. In addition, before rating any products from a given task, the judge carefully read through the task itself, noting its specific requirements. Having separated all products into "high," "medium," and "low" categories, he reread the tasks and products, separating the "high" and "low" products into two subcategories, and dividing the middle pile into three sections. The rating procedure was designed to result in judgments along a seven-point scale of adequacy and creativity scores, both within a single task and across tasks. That is, the center pile (number four) should have contained products from several tasks, all of equal adequacy or creativity with respect to the particular requirements of the tasks which gave rise to them. Descriptions of the Adequacy and Creativity scales, including the directions given to raters on these scales, may be found in the Appendix.

B. Event Records

In the Individual condition, the E noted the behavior of each individual at one-minute intervals. From these observations, the motivation score for each man was the proportion of entries which fell in categories other than "bored, no activity." His efficiency or coordination score was taken as the proportion of entries indicating task behavior.

In the Group condition, event recording included both photographs and tape recordings. From the photos and the cameraman's form an activity score was computed for each man by totalling the number of times he spoke during the session, and the number of entries for him in categories "writing," "hands/arms move," "body moves," and "head moves." A more detailed discussion of the method of viewing films and deriving scores is presented in Stapert (1969).

For each task performed by a group, the tape recording was rated by undergraduate assistants using a time-sampling procedure. Ratings were made of five-second intervals one minute apart, for the duration of the task. The average number of speakers per interval was used as an index of motivation or activity; an inverse measure of activity was the proportion of total entries which were rated as "silence." The difference between the number of entries which were rated "about task" versus "not about task," divided by the total number of ratable entries, served as an indication of coordination.

Finally, the proportion of entries during which speakers overlapped or interrupted each other was taken as a measure of lack of coordination. Measures derived from the tape recordings were expressed as proportions of the total number of entries since groups varied considerably in the number of segments sampled due to the fact that their completion times varied from two to fifteen minutes.

C. Self-, Peer-, and Observer-Ratings

After each task in the Individual condition, Ss rated themselves and each other man in the group on activity; these self- and peer-ratings, in addition to similar ratings made by the E, served as indices of individual motivation. Ratings on a scale measuring task activity were used as measures of coordination or efficiency in the Individual condition.

Post-task ratings in the Group condition included self-, peer-, and observer-ratings, of each man in the group, and of the group as a whole. Ratings on two scales assessing amount of talking and movement were combined to yield one index of motivation for each man in the group. An additional scale concerning interest in group activity was also used to indicate individual motivation. A single item, "Functioned smoothly in group's task performance/ Obstructed group's task performance," was designed to measure the coordination attributed to each man in the group.

The coordination of the group as a whole was estimated by the scale "Pooled resources smoothly in task performance/ Confusion in task performance," and a final scale indexed the activity level or motivation of the group.

CHAPTER IV: RESULTS

A. Preliminary Investigations of the Data

The central data in the present research consist of ratings of products on general and task-dependent dimensions. Since this experiment follows closely the Hackman (1966) methodology, it is of some interest to establish the comparability of these data to those of Hackman.

Reliabilities of Product Ratings

Table 1 presents the average intercorrelation among the three raters on each scale, which is taken as an indication of the reliability of ratings on the scale. These values range from .27 to .87 with a median average intercorrelation of .51. Table 1 also reports reliabilities of the average rating of all judges for each scale; these reliabilities fall between .77 and .98 with a median value of .90.

Table 2 presents reliabilities for single scales reported by Hackman (1966) and the number of ratings on which these reliabilities are based. For purposes of comparison the table also reports reliabilities of product ratings in the present experiment, adjusted to the number of ratings used by Hackman.

Reliabilities reported by Hackman represent ratings of 432 products, four from each of 108 groups and 108 tasks. In contrast, figures in the present study are based on ratings of products from only 12 tasks; both individual and group products are represented in these product sets.

Table 1

Reliabilities and Adjusted Reliabilities
of Product Ratings on 20 Scales

Dimension or Scale	Average Intercorrelation among Three Raters	Adjusted Reliability
I. Action Orientation		
Suggests action	.68	.95
Constructive	.60	.93
Passive	.42	.87
II. Length		
Short	.87	.93
Number of words ^a		
Lacks detail	.77	.97
III. Originality		
Bizarre	.44	.88
Not unusual	.56	.92
Original	.51	.90
IV. Outlook		
Positive Outlook	.46	.88
Supportive	.37	.84
Disapproves	.32	.81
V. Quality of Presentation		
Choppy	.61	.93
Stylistically well-integrated	.40	.86
Understandably presented	.27	.77
VI. Issue Involvement		
Low issue involvement	.53	.91
Propagandistic	.65	.94
States a belief	.73	.96
VII. Adequacy ^b	.49	.90
VIII. Creativity ^b	.49	.90

^aThis is an "operational" scale involving counting the number of words; since only one rating was used, no reliability data is presented.

^bThese are task-dependent dimensions, each defined by only one scale.

Table 2

Comparison of Present Reliabilities with
Those Reported by Hackman (1966)

Dimension or Scale	Hackman Reliability	Low Reliability (Adjusted)
I. Action Orientation		
Suggests action	.95	.91
Constructive	.96	.88
Passive	.93	.78
II. Length		
Short	.98	.97
Number of words ^a		
Lacks detail	.90	.94
III. Originality		
Bizarre	.90	.80
Not unusual	.90	.86
Original	.90	.84
IV. Outlook		
Positive outlook	.83	.81
Supportive	.86	.75
Disapproves	.84	.70
V. Quality of Presentation		
Choppy	.88	.89
Stylistically well-integrated	.75	.77
Understandably presented	.80	.65
VI. Issue Involvement		
Low issue involvement	.86	.85
Propagandistic	.87	.90
States a belief	.91	.93
VII. Adequacy ^b	.91	.94
VIII. Creativity ^b	.90	.96

Note.--Hackman values are the projected reliabilities of the average rating of 5 judges, for all scales except Adequacy and Creativity. Hackman used 16 and 25 raters for these two scales, respectively. Lowe values are average intercorrelations projected to the number of raters used by Hackman.

^aThis is an operational scale; no reliabilities are given.

^bThese are task-dependent dimensions, each defined by only one scale.

Effects of Task Type, Condition Sequence, and Task Order on Product Dimensions

A second type of preliminary analysis was performed (1) to examine further the comparability of the present data to those of Hackman (1966), and (2) to determine the cells of the design from which data might be combined in the prediction of group performance. Following Hackman, ratings were averaged across three raters per scale, and across the three scales composing each general dimension, to yield eight scores for each product: six general dimensions (Action Orientation, Length, Originality, Outlook, Quality of Presentation, and Issue Involvement), and two task-dependent dimensions (Adequacy and Creativity). A ninth dependent variable, Time to Solution, was analyzed in the same fashion as the eight product dimension scores.

Previous research (Hackman, 1965a, 1966) has shown task type to be a potent variable in determining values of product dimensions. Therefore, it was anticipated that the present experiment would replicate the product dimension profiles reported by Hackman for production, discussion, and problem-solving tasks. Furthermore, since the design of this research counterbalanced two condition sequences (group to individual and individual to group) and four task positions (first, second, third and fourth), it was necessary to determine what effects these variables might have upon product dimension scores. If condition sequence and task order were found not to alter significantly the values of the dependent variables, then levels of these variables could be combined to yield larger sample sizes for later analyses. The analysis of variance design used to test effects of these three variables is illustrated in Figure 2.

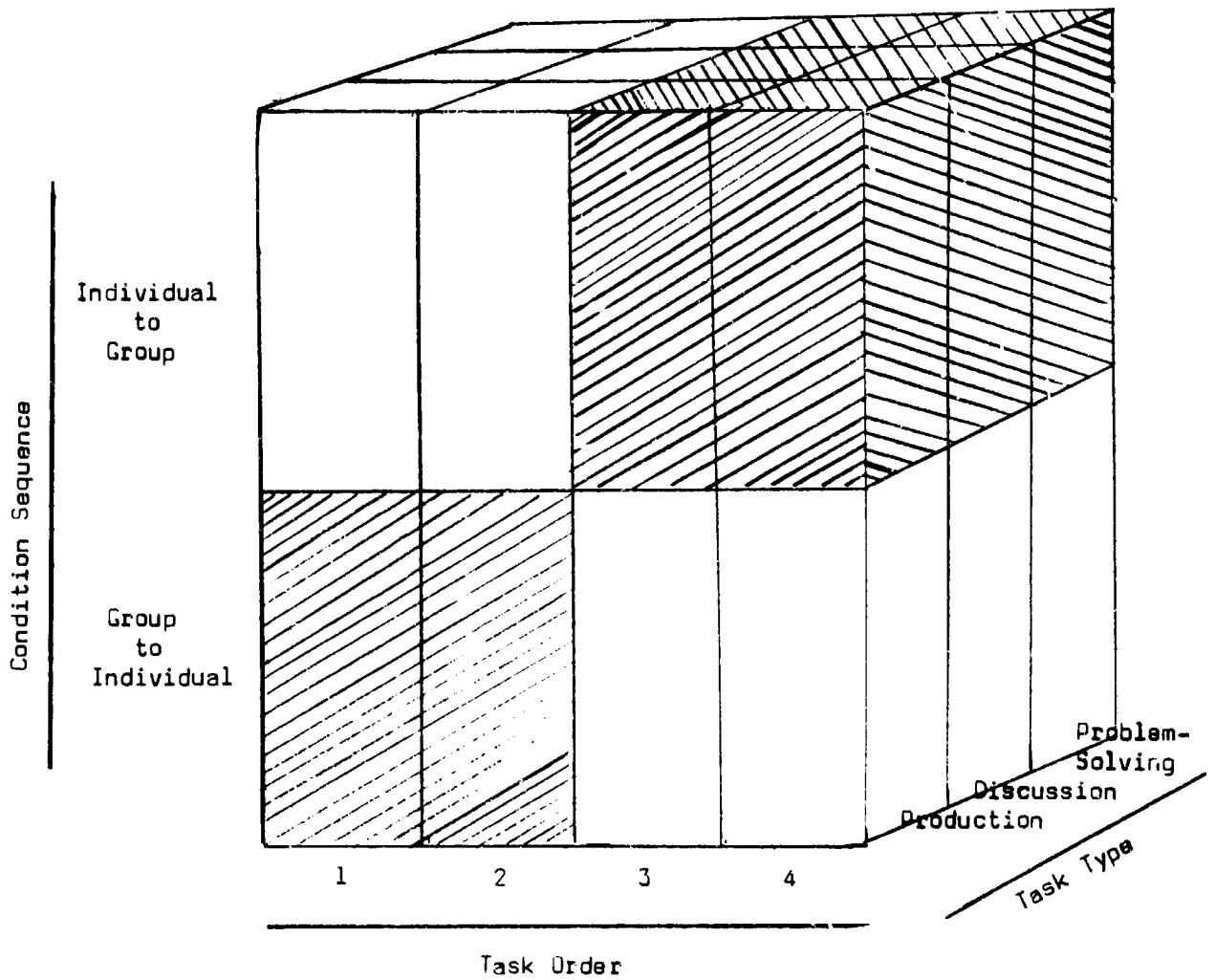


Figure 2. Design of Preliminary Analysis of Variance

Shaded cells contain group data, while unshaded portions represent data collected from coacting individuals.

A given four-man group performed tasks of only one type, and worked in only one condition sequence. However, the design incorporates repeated measures on the variable of task order, since the four men in a group did perform one task in each of the four serial positions. (As indicated on Figure 2, for individual-to-group subjects, tasks one and two were performed individually while tasks three and four were group tasks. On the other hand, subjects in the group-to-individual condition sequence worked as groups on tasks one and two, and individually on the third and fourth tasks.)

While every task performed by a group yielded only one product, the same four men working on a task in an Individual session generated four products. For this reason, the four individual scores for a given task were combined so that one representative score could be contrasted with a product score for the same men working in a group. Three different combinations (minimum, maximum, and average) were suggested by models to be tested in later analyses. Thus, a three-way analysis of variance of the type described above was performed for each of nine dependent variables (eight product dimensions and time), and for each of three forms of individual data. Nine analyses of variance took, as individual data, the minimum score within a coacting group. A second nine analyses used the maximum of four individual scores, while the final nine analyzed the average of the four scores. A total of 27 analyses of variance were performed. The following sections report similarities between the present data and those of Hackman (1966), supporting generalization among the two studies. These results also pertain to the question of which portions of the data should or should not be combined in later analyses aimed at predicting characteristics of group performance from individual data. A more detailed presentation

of results from these analyses of variance, including complete summary tables and tables of means, may be found in the Appendix.

Task type: For all product dimensions except Adequacy, Hackman (1966) reports significant differences ($p < .01$) in product dimensions as a function of task type. The main effects of task type on the nine dependent variables in the present experiment are summarized in Table 3. The table presents values of F and significance levels for the main effects of task type in the 27 analyses of variance described above. Of the 27 values, all show statistical significance; 23 indicate differences significant at less than the .001 level.

These strong and consistent differences in all nine dependent variables as a function of task type have implications for later analyses. The prediction of group product characteristics from individual data within task type may give additional information which would be obscured by an analysis of the combined data from all three task types.

Means and standard deviations of group products on the nine dependent variables are presented in Table 4. The table also contains mean values reported by Hackman (1966) for three task types on the eight product dimensions, for purposes of comparison with data from the present research.

The patterns of means from the two studies are quite similar, although values obtained in this research are generally lower than those of Hackman. In the present experiment, the rank order of task types replicates that reported by Hackman on five of the eight product dimensions. Two of the three dimensions on which this rank order is not duplicated (Outlook and Creativity) involve inversions of two means which differ by less than .5 of a scale value in the original Hackman research. Although in 10 cells the Hackman means are more than one standard

Table 3

Values of F for Main Effect
of Task Type on Nine Dependent Variables
in Analyses Using Three Types of Individual Data

	Minimum Individual Score	Maximum Individual Score	Average Individual Score
Action Orientation	1805.80***	1999.94***	2441.77***
Length	9.71***	5.99**	7.91***
Originality	177.15***	106.69***	180.33***
Outlook	22.39***	34.59***	39.76***
Quality of Presentation	12.10***	17.44***	15.13***
Issue Involvement	630.61***	670.54***	780.87***
Adequacy	3.78*	6.19**	6.27**
Creativity	11.11***	14.61***	14.55***
Time to Solution	9.80***	14.06***	12.63***

* $p < .05$

** $p < .01$

*** $p < .001$

Table 4

Comparison of Lowe and Hackman (1966)
Product Dimension Means for Group Products
of Three Task Types

	Production		Discussion		Problem-Solving	
	Lowe	Hackman	Lowe	Hackman	Lowe	Hackman
General Dimensions ^a						
Action Orientation ^b	1.72 ^d $\sigma=.23$	2.75	2.74 ^d $\sigma=.39$	3.95	5.89 $\sigma=.40$	5.81
Length ^b	3.53 $\sigma=1.30$	4.73	2.72 $\sigma=.95$	3.59	2.25 $\sigma=1.02$	3.18
Originality ^b	3.80 $\sigma=.02$	4.76	2.06 ^d $\sigma=.43$	2.72	2.03 ^d $\sigma=.41$	2.49
Outlook	3.79 $\sigma=.54$	3.88	4.37 $\sigma=.52$	4.13	4.29 ^d $\sigma=.23$	4.64
Quality of Presentation	3.45 ^d $\sigma=.81$	5.07	4.13 $\sigma=.98$	4.38	3.54 $\sigma=.79$	3.77
Issue Involvement ^b	1.66 ^d $\sigma=.23$	3.06	4.62 ^d $\sigma=.67$	5.39	2.26 ^d $\sigma=.65$	3.93
Task-Dependent Dimensions ^a						
Adequacy ^b	4.51 $\sigma=.82$	5.11	3.54 ^d $\sigma=.88$	4.97	4.22 $\sigma=.95$	5.10
Creativity	3.30 $\sigma=1.00$	3.09	2.61 $\sigma=.74$	2.44	2.11 $\sigma=.88$	2.77
Time to Solution ^c	13.34 $\sigma=2.09$		13.31 $\sigma=2.66$		10.86 $\sigma=2.66$	

Note.--Hackman (1966) does not report standard deviations.

^aScales for these dimensions run from 1 to 7.

^bDimensions on which task types follow the same rank order in Hackman data and in present study.

^cThis variable was not included in the original Hackman research. Values are in minutes; maximum possible time to solution = 15.00 minutes.

^dCells in which Lowe means are more than 1 σ from original Hackman means.

deviation from comparable means in the present data, eight of these cases occur on dimensions on which the rank order of task types is replicated.

Condition sequence. The main effect of condition sequence shows statistical significance in only four of 27 analyses of variance, as indicated in Table 5. The table presents values of F and significance levels for analyses of nine dependent variables, using three types of individual data.

Three of the four significant F values occur on the three analyses of one dimension, Originality. With the additional exception of Outlook when minimum scores provide the individual data, the sequence in which Ss complete the Individual and Group sessions does not significantly affect product dimension scores on Time to Solution. Values of means corresponding to the significant differences on the dimensions of Originality and Outlook are presented in Table 6.

Ss who work first as individuals and then in groups generate products which are significantly more original than those produced by Ss in the group-to-individual condition. This main effect of condition sequence occurs regardless of the type of individual data (minimum, maximum, or average) used; since it is a main effect, it includes all task types, and both individual and group data.

The significant main effect of condition sequence in the "minimum" analysis indicates that the lowest individual score within a group, and the group's score, are significantly more positive in Outlook for the products of Ss in the group-to-individual sequence than for Ss in the individual-to-group condition.

Task order: Table 7 presents F values and significance levels

Table 5
 Values of F for Main Effect of Condition Sequence
 on Nine Dependent Variables
 Using Three Types of Individual Data

	Minimum Individual Score	Maximum Individual Score	Average Individual Score
Action Orientation	.08	.23	.18
Length	.35	1.95	.99
Originality	4.00*	6.20*	5.09*
Outlook	5.72*	1.63	2.84
Quality of Presentation	.48	.26	.48
Issue Involvement	.26	.11	.15
Adequacy	.02	.18	.39
Creativity	.98	2.24	1.30
Time to Solution	.04	.02	.08

*p < .05

Table 6
Means
for Originality (Three Analyses) and Outlook (One Analysis)
for Two Condition Sequences

	Individual to Group Sequence	Group to Individual Sequence
	Means	Means
<u>Originality</u>		
Minimum Individual Score	2.54	2.39
Maximum Individual Score	3.36	3.08
Average Individual Score	2.90	2.71
<u>Outlook</u>		
Minimum Individual Score	3.74	3.93

Table 7
 Values of F for Main Effect of Task Order
 on Nine Dependent Variables
 Using Three Types of Individual Data

	Minimum Individual Score	Maximum Individual Score	Average Individual Score
Action Orientation	1.16	.85	1.01
Length	.27	1.07	.54
Originality	.67	.36	.42
Outlook	.16	1.28	1.04
Quality of Presentation	.82	1.34	1.21
Issue Involvement	.13	.47	.15
Adequacy	.82	.81	.51
Creativity	.83	1.86	1.24
Time to Solution	2.48	2.68*	2.57

*p < .05

for the effects of task order on nine dependent variables, when three kinds of individual scores are used in the analyses of variance.

A significant difference as a function of task order occurs in only one of the 27 analyses of variance, that which uses the maximum individual score on Time to Solution.* The general lack of significant differences as a function of task position suggests that data from different serial positions may legitimately be combined in later analyses.

Comparison of Individual with Group Data

Although the analysis of variance design does not permit extraction of a main effect for the difference between group and individual products, it is of some interest to compare the two. Post-hoc comparisons have been used to test the significance of the differences between the cell means containing individual products and those involving the products of groups, as indicated in Figure 2 (see page 37).

In the design, variance due to the difference between individual and group products appears in the interaction term for condition sequence \times task order. In each analysis of variance in which this interaction was shown to be significant by the F test, a comparison was performed to determine if this significance might be due to the difference between individual and group products. Table 8 presents F values and their probability levels, and the significance levels of the corresponding comparisons, by dimension and type of individual data involved.

The condition sequence \times task order interaction showed statistical significance in 21 of the 27 analyses of variance. In 14 of the 21 corresponding comparisons, individual and group products were significantly

*The means for the significant comparison, maximum individual scores on Time to Solution, were 13.19, 12.70, 12.10, and 12.16 minutes for the 1st, 2nd, 3rd, and 4th tasks respectively.

Table 8

Significance Levels for Comparisons of
Individual and Group Products for Analyses with
Significant Condition Sequence by Task Order Interaction

Dimension and Type of Individual Data	F Value and Significance Level for C.S. by T.O. Interaction		Significance Level for Individual-Group Comparison
Action Orientation:			
Minimum Individual Score	11.08	$p < .001$	$p < .01$
Maximum Individual Score	10.54	$p < .001$	$p < .01$
Length:			
Maximum Individual Score	89.47	$p < .001$	$p < .01$
Average Individual Score	31.47	$p < .001$	$p < .01$
Originality:			
Minimum Individual Score	2.63	$p < .05$	ns
Maximum Individual Score	27.16	$p < .001$	$p < .01$
Average Individual Score	3.12	$p < .05$	ns
Outlook:			
Minimum Individual Score	20.22	$p < .001$	ns
Maximum Individual Score	32.52	$p < .001$	ns
Quality of Presentation:			
Maximum Individual Score	59.52	$p < .001$	$p < .01$
Average Individual Score	19.06	$p < .001$	$p < .01$
Issue Involvement:			
Maximum Individual Score	51.08	$p < .001$	$p < .01$
Average Individual Score	16.31	$p < .001$	$p < .01$
Adequacy:			
Minimum Individual Score	7.47	$p < .001$	ns
Maximum Individual Score	42.61	$p < .001$	$p < .01$
Average Individual Score	4.13	$p < .01$	ns
Creativity:			
Minimum Individual Score	3.31	$p < .05$	ns
Maximum Individual Score	81.75	$p < .001$	$p < .01$
Average Individual Score	14.78	$p < .001$	$p < .01$
Time to Solution:			
Minimum Individual Score	43.35	$p < .001$	$p < .01$
Average Individual Score	11.69	$p < .001$	$p < .01$

different at the .01 level. Table 9 presents mean values for individual and group products in the analyses in which comparisons were performed. Sets of means which led to significant comparisons are indicated by an asterisk.

Consideration of Individual-Individual Ss

The present experiment included 40 Ss who performed for two hours in the Individual condition, rather than for one hour as individuals and one hour as groups. These Ss were incorporated into the study as a means of investigating the consistency of individual performance over a two-hour span; if individual output itself changes significantly and unpredictably during that period, the prediction of group performance from individual performance over the same time span would seem difficult. Two types of analysis were conducted to investigate this question.

Comparison of I-I Ss with G-I and I-G Ss: A two-way analysis of variance design was used to compare I-I Ss with those who worked under both Individual and Group conditions. Subject population (I-G or G-I versus I-I) and task order (first versus second, or third versus fourth) are the two factors in the design, which includes repeated measures on the second factor. Since the I-I Ss worked on problem-solving tasks, the comparable I-G and G-I Ss are those assigned to the same task type. Only their individual data are included in the analysis since the I-I Ss did not work in the Group condition.

For the first two tasks completed by the I-I Ss, the appropriate comparison data are those from the I-G Ss, who worked on the first two tasks as individuals. Similarly, the third and fourth tasks for the I-I Ss are compared with the individual data for G-I Ss, who completed the third and fourth tasks as individuals. Two separate but comparable sets

Table 9

Mean Values of Individual and Group Products
for Analyses with Significant Interaction of
Condition Sequence and Task Order

Dimension and Type of Individual Data	Mean Individual Scores	Mean Group Scores
Action Orientation:		
Minimum Individual Score ^a	3.02	3.42
Maximum Individual Score ^a	3.81	3.42
Length:		
Maximum Individual Score ^a	5.31	2.84
Average Individual Score ^a	4.26	2.84
Originality:		
Minimum Individual Score	2.31	2.63
Maximum Individual Score ^a	3.82	2.63
Average Individual Score	2.90	2.63
Outlook:		
Minimum Individual Score	3.52	4.15
Maximum Individual Score	4.82	4.15
Quality of Presentation:		
Maximum Individual Score ^a	5.14	3.71
Average Individual Score ^a	4.49	3.71
Adequacy:		
Minimum Individual Score	3.43	4.10
Maximum Individual Score ^a	5.57	4.10
Average Individual Score	4.54	4.10
Creativity:		
Minimum Individual Score	2.24	2.62
Maximum Individual Score ^a	4.68	2.62
Average Individual Score ^a	3.43	2.62
Time to Solution: ^b		
Minimum Individual Score ^a	8.63	12.50
Average Individual Score ^a	10.67	12.50

^aCases in which comparison is significant at $p < .01$.

^bThe figures for this dimension represent number of minutes.

of nine analyses of variance (one for each dependent variable) were therefore performed, as illustrated in Figure 3.

Table 10 summarizes results of the 18 analyses of variance which pertain to the comparability of the two subject populations (I-I and I-G/G-I). The table presents mean values for both subject groups on the nine dependent variables, along with values of F and significance levels for the main effects of subject population.

Products of I-I Ss do not differ significantly from those of Ss in the main design on the dimensions of Action Orientation, Length, Originality, Quality of Presentation, or Creativity. However, on four dimensions the two subject populations do show mean differences which are significant at the .01 level or less. In three of these four cases (Outlook, Issue Involvement, and Adequacy) a significant difference occurs in both analysis I and analysis II; since the two analyses may be interpreted as replications of each other, this is a strong indication that the obtained differences are not merely chance results, but in fact represent actual differences between products of the two groups of Ss. On these dimensions, then, conclusions based on data from the I-I Ss have limited population generalizability.

The main effects of task order in the 18 analyses are summarized in Table 11, which presents mean dependent variable scores, values of F , and levels of significance for these values.

In only four of the 18 analyses is there a significant effect of task order. In all four cases, significant differences occur between the first and second tasks; Ss take more time and write longer products of better quality and greater creativity on their first task than on their second. There are no significant differences between the third and fourth tasks.

ANALYSIS I:

	I-I <u>Ss</u>	I-G <u>Ss</u>
Task 1	N = 40	N = 48
Task 2	N = 40	N = 48

ANALYSIS II:

	I-I <u>Ss</u>	G-I <u>Ss</u>
Task 3	N = 40	N = 48
Task 4	N = 40	N = 48

Figure 3. Design for Analysis of Variance of the Effects of Subject Population and Task Order on Nine Dependent Variables.

Table 10
Mean Values of Nine Dependent Variables
for Two Subject Populations, and Corresponding F Values

Variable	I-I Mean N=40	I-G or G-I Mean N=48	Value of F
Action Orientation I	5.82	5.66	2.39
Action Orientation II	5.87	5.80	.71
Length I	4.11	4.27	.45
Length II	3.33	3.51	.57
Originality I	2.24	2.28	.12
Originality II	2.26	2.19	.20
Outlook I	4.11	4.45	9.93*
Outlook II	4.15	4.44	10.86*
Quality of Presentation I	4.69	4.84	1.10
Quality of Presentation II	4.35	4.52	1.18
Issue Involvement I	4.30	3.46	23.99**
Issue Involvement II	3.81	3.16	9.75*
Adequacy I	5.16	4.62	9.87*
Adequacy II	5.06	4.47	12.46*
Creativity I	3.06	3.04	.02
Creativity II	2.83	2.76	.11
Time to Solution I ^a	9.61	9.71	.05
Time to Solution II ^a	6.97	8.68	10.37*

Note.--Analysis I uses data from the first and second tasks, while Analysis II considers the third and fourth tasks.

^aMeans for this variable are given in minutes.

* $p < .01$

** $p < .001$

Table 11
Means of Nine Dependent Variables
as a Function of Task Order, and Corresponding F Values
(I-I and I-G/G-I Subjects, N = 88)

Variable	Mean, First (Third) Task	Mean, Second (Fourth) Task	F
Action Orientation			
1 vs. 2	5.74	5.72	.04
3 vs. 4	5.76	5.91	2.34
Length			
1 vs. 2	4.51	3.89	6.60**
3 vs. 4	3.31	3.54	1.00
Originality			
1 vs. 2	2.33	2.20	.64
3 vs. 4	2.12	2.35	2.33
Outlook			
1 vs. 2	4.25	4.35	1.10
3 vs. 4	4.35	4.27	.78
Quality of Presentation			
1 vs. 2	4.89	4.65	4.83*
3 vs. 4	4.39	4.49	.67
Issue Involvement			
1 vs. 2	3.97	3.72	1.96
3 vs. 4	3.43	3.48	.06
Adequacy			
1 vs. 2	4.80	4.93	.53
3 vs. 4	4.68	4.79	.34
Creativity			
1 vs. 2	3.25	2.85	4.53*
3 vs. 4	2.63	2.96	3.09
Time (in minutes)			
1 vs. 2	10.56	8.78	8.99**
3 vs. 4	7.91	7.89	.00

* $p < .05$ ** $p < .025$

In no case was there a significant interaction between subject population and task order.

Temporal trends for I-I Ss: A set of nine one-way analyses of variance with repeated measures was performed on data from the I-I Ss to determine the consistency of individual performance over a two-hour period. Table 12 gives mean values of the nine dependant variables for four task positions, along with values of F and their significance levels.

Three variables show significant variation as a function of task position: Length of the product, its Quality of Presentation, and its Time to Solution. Length and Quality show a decrease from the first to the second, a smaller decrease to the third, and then an increase on the fourth task. Time to Solution shows a consistent decrease for successive tasks.

Significant effects of task position on the variables of Length, Quality of Presentation, and Time were found in the comparison of I-I Ss with other problem-solving Ss, as well as in the analysis presently under discussion. This is hardly surprising, since the former analysis includes all data treated by the latter. However, the effects of task order in the I-I versus I-G/G-I analysis were significant only for the first versus second tasks; differences in these variables from the third to the fourth task were not statistically significant. This would suggest that some sort of warm-up effect may occur at least for problem-solving tasks at the beginning of the experimental session, on the variables of Length, Quality of Presentation, and Time to Solution.

B. Prediction of Group Output Characteristics from Individual Product Data

The central purpose of this study was to investigate the relationships between certain characteristics of individual output and measures of

Table 12
 Mean Values of Nine Dependent Variables
 for Four Task Positions, and Corresponding Values of F
 (I-I Subjects, N = 40)

Variables	Task 1	Task 2	Task 3	Task 4	F
Action Orientation	5.75	5.88	5.74	6.00	1.05
Length	4.62	3.60	3.19	3.47	7.50*
Originality	2.32	2.15	2.15	2.23	.21
Outlook	4.09	4.14	4.20	4.10	.23
Quality of Presentation	4.89	4.48	4.30	4.39	5.16*
Issue Involvement	4.55	4.04	3.78	3.84	2.61
Adequacy	4.98	5.34	4.93	5.19	1.03
Creativity	3.39	2.75	2.68	2.98	2.39
Time to Solution ^a	10.63	8.60	7.10	6.84	10.67*

^aValues for this variable are given in minutes.

*p < .01

those characteristics of products when the same individuals are working as groups. The following sections will report results concerning these relationships.

The strategy for this analysis has been to combine individual data according to three of the models (conjunctive, disjunctive, and compensatory) which Steiner (1956) describes and to correlate these combinations with groups' scores. When the score of the group member with the lowest (minimum) score is highly correlated with group output, the conjunctive model is appropriate. When the score of the member with the highest (maximum) individual score correlates with group performance, then the disjunctive model is applied. High correlations between the average individual score and the group score would lend support to the compensatory model (or to the additive model, which is indistinguishable from the compensatory model within this study design since all groups were 4-man groups).

Each S completed two tasks as an individual and two as part of a group. Data from task one and task two in each session were used, both separately and in combination. In the interest of brevity and clarity, this section will consider only correlations based on scores from tasks one and two combined, since these scores are likely to be more stable than scores on single tasks.

Prediction for All Task Types Combined

Table 13 reports correlations between individual measures and corresponding group measures, based on all 72 groups in the design. Correlations are presented for each of nine dependent variables, using each of three models to combine individual scores. That is, the lowest score of a group member on both individual tasks is paired with the lower of the scores obtained by his group on its two tasks; these

Table 13

Values of r for Three Models
for Prediction of Dimensions of Group Products
from Individual Scores on the Same Dimensions
(All Task Types Combined, $N = 72$)

	Minimum Model ^a	Maximum Model ^b	Average Model ^c
Action Orientation	.94**	.92**	.96**
Length	-.02	.19	.07
Originality	-.09	.51**	.44**
Outlook	.11	.19	.28*
Quality of Presentation	.23*	.04	.15
Issue Involvement	.84**	.67**	.81**
Adequacy	-.05	-.02	-.06
Creativity	-.05	.22	.13
Time to Solution	.58**	.34**	.57**

^aCorrelations between the lowest of the eight scores on both individual tasks, and the lower of the two group scores.

^bCorrelations between the highest of the eight scores on both individual tasks, and the higher of the two group scores.

^cCorrelations between the average of the eight scores on both individual tasks, and the average of the two group scores.

* $p < .05$

** $p < .01$

two values are then correlated over all groups. In a similar fashion, the maximum score on either individual task is correlated with the higher of the group's two scores, and the average score of all individuals in a group is correlated with the average score for both of that group's tasks. These three correlations correspond to the conjunctive, disjunctive, and compensatory models, respectively.

From inspection of the table it is clear that certain dimensions can be predicted well using more than one model, while other dimensions are virtually unpredictable using any of the models considered. There are very significant correlations (.94, .92, and .96) for Action Orientation for the minimum, maximum, and average models, respectively. All three models also show significant correlations for Issue Involvement (.84, .67, and .81) and for Time (.58, .34, and .57), and both the maximum and average models show significant correlations for Originality (.51 and .44). On the other hand, none of the models predicts significantly for the dimensions of Length, Adequacy, or Creativity. Only one model predicts significantly for Outlook (average model, $r = .28$) and for Quality of Presentation (minimum model, $r = .23$), and these correlations, though marginally significant ($p < .05$) are considerably lower than those reported for Action Orientation, Issue Involvement, Time, and Originality.

Prediction within Task Types

Since previous research (Hackman, 1965a, 1966) and results already cited from the present study indicate that considerable variability on product dimensions can be attributed to task type, prediction of group from individual scores was also attempted within each task type separately. Table 14 presents zero-order correlations for the three models on each of the nine dependent variables, by task type. That table also presents a multiple correlation for each dimension and each type, indicating the predictability of group task two from the second individual task.

Table 14

Values of r and R
for Four Models for the Prediction of Dimensions
of Group Products from Individual Scores
on the Same Dimensions
(Separately for Each Task Type, $N = 24$)

	Minimum Model ^a	Maximum ^b	Average ^c	Multiple Linear Regression ^d
Action Orientation				
Production	-.29	-.12	.03	.37
Discussion	-.56**	-.32	-.47*	.36
Problem-Solving	.43*	-.11	.10	.69**
Length				
Production	-.14	-.08	-.12	.47
Discussion	-.17	.20	.08	.42
Problem-Solving	.09	.28	.29	.30
Originality				
Production	-.74**	-.00	-.51**	.49
Discussion	.52**	-.10	.12	.34
Problem-Solving	-.42*	.11	-.26	.58
Outlook				
Production	-.11	.04	.22	.22
Discussion	-.24	.08	-.38	.41
Problem-Solving	.27	-.47*	-.13	.50
Quality of Presentation				
Production	-.19	-.36	-.39	.60
Discussion	.50*	.22	.45*	.64*
Problem-Solving	-.04	.06	-.07	.35
Issue Involvement				
Production	.16	-.37	-.38	.69**
Discussion	-.38	-.31	-.56**	.70**
Problem-Solving	.19	-.43*	-.33	.72**
Adequacy				
Production	-.27	-.19	-.33	.63**
Discussion	.07	.03	-.04	.64*
Problem-Solving	.04	-.08	.14	.61*

Table 14--Continued

	Minimum Model ^a	Maximum ^b	Average ^c	Multiple Linear Regression ^d
Creativity				
Production	-.05	-.16	-.15	.66*
Discussion	.11	.17	.25	.55
Problem-Solving	.00	.37	.21	.38
Time to Solution				
Production	.30	.17	.36	.67*
Discussion	.62**	.48*	.65**	.66*
Problem-Solving	.32	.25	.32	.57

^aCorrelations between the lowest of the eight scores on both individual tasks, and the lower of the two group scores.

^bCorrelations between the highest of the eight scores on both individual tasks, and the higher of the two group scores.

^cCorrelations between the average of the eight scores on both individual tasks, and the average of the two group scores.

^dMultiple correlations of four individual scores ranked in order of decreasing size, and the group score. Prediction is from the second individual task to the second group task.

* $p < .05$

** $p < .01$

Zero-order correlations: The pattern of zero-order correlations for the three basic models appears quite different when task types are separated than when they are combined as in Table 13. For example, all three models predict Action Orientation for all task types combined. Within task type, however, only the minimum model predicts Action Orientation significantly for problem-solving tasks (.43). Discussion tasks are predictable, but with a negative relation, using the minimum (-.56) or average (-.47) models, while no model shows a significant r for production tasks.

On the dimension of Originality the maximum model, which correlated significantly for combined task types, does not do so within any task type. The average model shows a significant relationship on Originality only for production tasks, and that is in a negative direction (-.51). Finally, although the minimum model does not predict significantly on Originality for combined task types, it shows strong relationships within each task type although two of the correlations are in a negative direction. For production, discussion, and problem-solving tasks, the correlations are -.74, .52, and -.42, respectively.

The Outlook dimension can be significantly predicted with the maximum model only for problem-solving tasks (-.47). This model does not show a significant relationship on this dimension for combined task types.

The significant correlation found for the minimum model on Quality of Presentation for combined task types persists only for discussion tasks (.50) when the types are separated. The average model, though not predictive for combined task types, becomes so (.45) for discussion tasks. Thus, two models (minimum and average) significantly predict Quality of Presentation on discussion tasks.

Although all three models predict significantly the Issue Involvement of group products for the combined sample, when data are separated by task type only one model predicts each of two types. For problem-solving tasks the maximum model shows a correlation of $-.43$, while the average model predicts Issue Involvement for discussion tasks ($-.56$).

Finally, the dimension of Time shows consistent predictability only for discussion tasks; all three models show statistically significant relationships ($.62$, $.48$, $.65$) for this task type. For the combined sample, all models predict as well.

No significant relationships occur on the dimensions of Length, Adequacy, or Creativity for any task type, using any model.

Multiple correlations: The multiple correlations presented in Table 14 are not directly comparable to the correlations for the three basic models, since they relate only group performance on the second task to individual performance on the second task. Still, the correlations presented give an indication of the maximum degree of predictability to be expected using these data.

On the dimension of Action Orientation, only problem-solving tasks can be successfully predicted with the linear regression model ($R = .69$). Once again, Length shows no significant correlations for any task type; the multiple regression model produces no significant correlations on either Originality or Outlook.

The Quality of Presentation of discussion tasks can be predicted with the regression model, as indicated by an R value of $.64$. For tasks of any type, Issue Involvement is predictable as well ($R = .69$, $.70$, and $.72$).

Only the multiple regression model has any success in the prediction of the task-dependent dimensions of Adequacy and Creativity. Production ($R = .63$), discussion ($R = .64$), and problem-solving ($R = .61$) tasks show significant multiple correlations for Adequacy; Creativity is predictable only for production tasks ($R = .66$).

Finally, multiple correlations on Time to Solution reach statistical significance for tasks of both production and discussion types ($R = .67, .66$).

Table 15 presents a summary of the models which predict each of the nine dependent variables, for each task type and for the three task types combined.

The Concepts of Motivation and Coordination

As noted in Chapter I, there has not been adequate investigation of Steiner's (1966) concepts of motivation and coordination as factors in the prediction of actual productivity from potential productivity. One secondary purpose of this study was to explore those concepts.

Certain conceptual and methodological problems arose in exploration of the motivation and coordination concepts. One problem had to do with how the concepts could best be operationalized. Should measures of motivation and coordination be taken on the group or on the individual member? If the latter, then should such measures be taken for the individual while operating in a group, or for the individual while performing alone? The concept of coordination connotes, if not requires, a group level definition, whereas the concept of motivation suggests an individual level construct. Furthermore, Steiner suggests that "motivation decrement" refers to the difference between a hypothetical condition when the individual is optimally motivated and the condition under which the group performance measure is to be obtained. But there is no compelling reason

Table 15

Summary of Models which Predict
Nine Group Scores ($p < .05$) for Three Task Types,
and for All Task Types Combined

	Ac.	Orn.	Length	Orig.	Int.	Q.P.	I.I	Ad.	Cr.	Time
Production:										
Minimum				X						
Maximum										
Average				X						
Multiple R							X	X	X	X
Discussion:										
Minimum	X			X		X				X
Maximum										X
Average	X					X	X			X
Multiple R						X	X	X		X
Problem-Solving:										
Minimum	X			X						
Maximum					X		X			
Average										
Multiple R	X						X	X		
All Task Types:										
Minimum	X					X	X			X
Maximum	X			X			X			X
Average	X			X	X		X			X

to assume that performance in the individual condition of this study is a good estimate of that hypothetical condition of optimal motivation. Indeed, there is considerable evidence (see, for example, Davis, in press; Zajonc, 1966) that at least for performance of well-learned responses (which the Hackman tasks probably elicit), the "alone" condition is less likely to involve optimal motivation (or arousal) than the Group condition of this study. So, in the present study design, both the Individual condition, from which the "predictor" sources or product dimensions are taken, and the Group condition, from which the "criterion" sources or product dimensions are taken, represent conditions of decrement (from a hypothetical optimum) in motivation, and perhaps similarly in coordination. It would not, therefore, be reasonable to expect actual group performance (as measured on group products) to equal potential group performance (as predicted from individual products) minus some measures of coordination and motivation derived from either the Individual or Group sessions. Without further clarification of the hypothetical optimum state of motivation and coordination, and some means to assess that state for the individual, the concepts of motivation and coordination in the Steiner models appear to be untestable.

Nevertheless, as noted in Chapter II, certain measures intended to represent coordination and motivation were obtained in this study. In accordance with the approach of the overall research project of which this study was a part, a multi-method approach was used in measurement of these two traits (motivation and coordination). The battery of measures included:

- a. Self-ratings, obtained from each S on questionnaire items designed to test motivation and coordination and administered after completion of each task.

- b. Peer-ratings, obtained by summing responses of the other group members about the S on the same items of the same questionnaire.
- c. Observer-ratings, obtained from the observer's responses about each S on the same questionnaire items.
- d. Audio time sample measures of coordination and motivation for the group, obtained from a tape recording of group conversation during task performance (as discussed in Chapter III).
- e. A photographic time sample measure of motivation, for each S, obtained from a time sample of photographs of each group during task performance.
- f. Event recording or objective records of the behavior of each S during the individual session.

Multitrait-multimethod matrices (Campbell and Fiske, 1959) for S and observer ratings as methods, and motivation and coordination as traits, are given in Tables 16 and 17. The first table represents ratings of groups during the Group session; the second pertains to ratings of individuals collected during the Individual session.

It is apparent that convergent validity of both traits (i.e., correlation between different measures of the same trait) is weak, relative to the method variance (i.e., correlation between the two traits measured by a single method). Furthermore, the separate items used to measure motivation and coordination fail to show acceptable "convergent and discriminant validity." A single item was used to measure coordination of individuals. Two items were included to tap motivation; one was intended to index arousal or activity level, while the second asked for a rating of the S's interest in the group's activity. Results indicated that each of the motivation items correlated with the coordination ratings almost as highly ($r = .50, .62$) as they correlated with each other ($r = .68$).

Table 16

Multitrait-Multimethod Matrix
for Subject and Observer Ratings
of Group Motivation and Coordination

	Method 1		Method 2	
	Subject Ratings		Observer Ratings	
	Motivation	Coordination	Motivation	Coordination
Subject Ratings				
Motivation	1.00	1		
Coordination	.73	1.00		
Observer Ratings				
Motivation	.27	.33	1.00	
Coordination	.24	.50	.47	1.00

Note.--Data were collected during group session.

Table 17

Multitrait-Multimethod Matrix
for Self & Peer and Observer Ratings
of Individual Motivation and Coordination

	Method 1 ^a		Method 2	
	Self & Peer Ratings		Observer Ratings	
	Motivation	Coordination	Motivation	Coordination
Self & Peer Ratings				
Motivation	1.11			
Coordination	.98	1.00		
Observer Ratings				
Motivation	.22	.21	1.00	
Coordination	.24	.23	.66	1.00

Note.--Data were collected during the individual session.

^aMethod 1 represents the sum of ratings of an individual by himself and three other Ss.

From these results, it is evident that the rating data do not provide measures of motivation or coordination which have adequate convergent and discriminant validity to warrant their use as indices in the Steiner prediction models.

Data from the event records, including audio and photographic records, were procured to yield potential indices of motivation and coordination. Inspection indicated these measures showed very little variation over groups. Hence they did not provide a feasible basis for use in conjunction with the Steiner prediction models.

It is also possible to view motivation decrement and coordination decrement, not as concepts which vary from individual to individual or group to group, but as concepts which reflect the effect of group size, and do so uniformly for any given size of group. Within the present design, then, we might consider the combined motivation-coordination decrement for four-man groups (versus "1-man groups") to be reflected in the difference between the mean scores for individuals on a given product dimension and the mean score for groups on that same product dimension. As indicated in Tables 8 and 9, there were significant differences between average member performance and group performance for five of the nine dependent variables (Length, Issue Involvement, Quality of Presentation, Creativity, and Time to Solution). In all cases except Time to Solution, the difference was in the direction of higher average scores on the dimension for individuals than for groups. This same direction held, but not significantly, for Adequacy and Originality. Individuals wrote longer products (in less time); their products were more issue involved, had a higher quality of presentation, and were more creative.

If the mean difference between individual and group product scores is considered to be the combined motivation-coordination "decrement," (or more generally, the "interactive process" decrement) for four-man versus one-man groups, it is clear that there were indeed significant decrements in Quality of Presentation, Length, Issue Involvement and Creativity, and a significant increment in Time to Completion (which is, of course, a decrement in "speed"). These results suggest that, at least for some attributes of written products, there is a substantial reduction or decrement for four-man groups compared to single individuals, presumably resulting from the interactive processes (motivation, coordination, etc.) going on within the group. These decrements merit further investigation.

CHAPTER V: DISCUSSION

The central purpose of the present investigation concerns the prediction of group performance characteristics from measures taken on individuals. Several other questions, however, are of secondary interest and bear further discussion.

A. Replication of Hackman Method and Findings

The present research uses the tasks and product rating methodology developed by Hackman (1965a, 1966); his results concerning the variables likely to effect product dimension scores were considered when this study was designed. For these reasons, it is of some interest to note the degree to which the present study has reproduced certain of Hackman's results.

Reliabilities of product ratings in this research are generally comparable to those reported by Hackman. Further, as indicated in Chapter III, the rank order of task types on the eight product dimensions generally follows that presented by him, although mean values in the present data are somewhat lower than his. The Hackman means reported in Chapter III (Table 4) represent data generated by three-man groups in response to 108 tasks, 36 of each of three types. In contrast, this research has used four-man groups and only 12 tasks, four of each type. Either of these variations could be responsible for the deviations

in mean values between the two studies.* The general similarity in the patterns of results, however, indicates that the present research has followed the Hackman methodology sufficiently to warrant some generalization from his results to this data.

B. Group versus Individual Performance

Prior research using the Hackman tasks (Hackman, 1965a, 1966; Kent, 1967; Morris, 1965) has considered the characteristics of products of three-man groups. Groups of size two through seven have been investigated in unpublished research by Hackman and Vidmar (personal communication). However, when the present study was designed no data had yet been collected on the characteristics of individual performance on these tasks. The present research can thus contribute new information on these tasks as tools in small-group research, since the difference between the performances of individuals and groups may in large measure reflect the effects of group processes.

Inspection of the data reported in Chapter III, and illustrated in Figure 4, shows a strikingly consistent result: group products generally show lower scale values on any dimension than do products of the average individual, whether data are taken from tasks of all three types, or for each type separately.

If Time to Solution is interpreted as speed (i.e., more time equals less speed), this generalization holds with the exception of

*An indication that the depression of mean scores in this research may be due to the use of a small sample of tasks (with many products from each task in a product set) is found in Stapert (1969). His mean product dimension values for each task type, obtained from three- and four-man groups and based on product sets including a small number of products from each of a large number of tasks, correspond to Hackman's with striking regularity. Since his Ss were a sample of those who participated in the present research, and his products were rated during the same time period and by the same judges as products in this research, the differences between the Hackman/Stapert means and those reported here cannot be due to these factors.

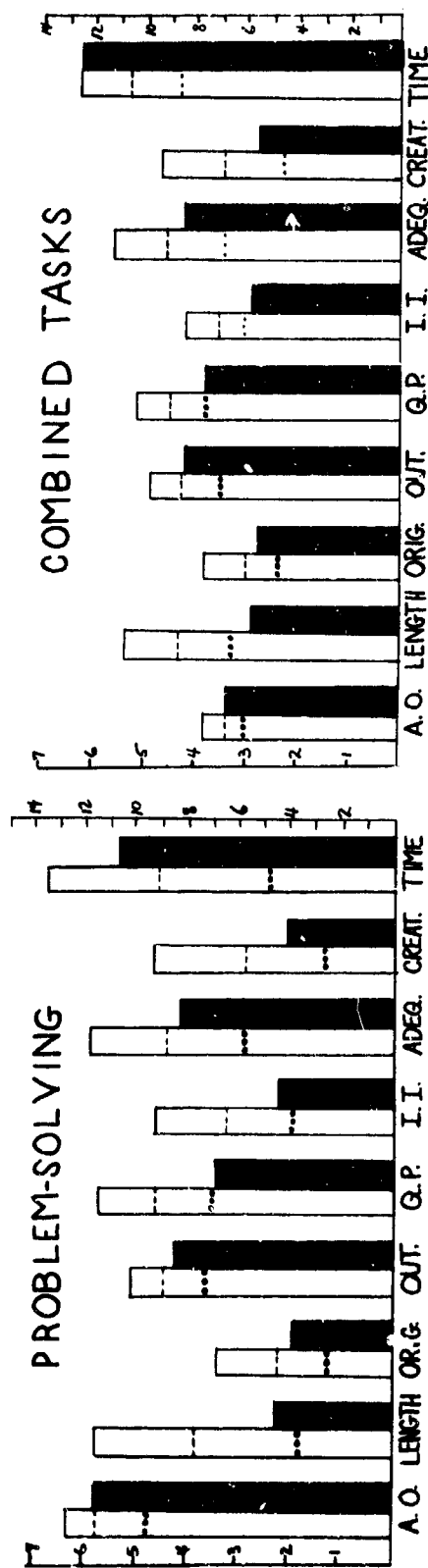
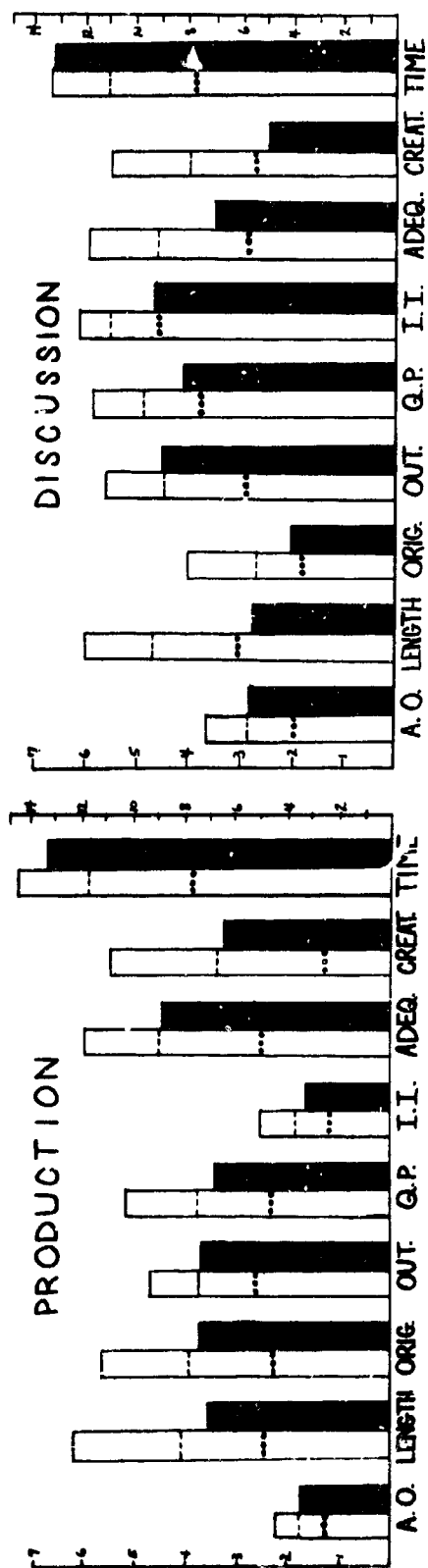


Figure 4. Comparison of Group Product Dimension Scores with Minimum, Average, and Maximum Individual Scores

Key: minimum indiv. = [---] average indiv. = [---] maximum indiv. = [■] group score = [■]

Outlook on discussion tasks, and the dimension of Action Orientation. On the latter dimension, group products show means very similar to those of the products of the average individual. Thus, not only the "best man," but also the average group member, working alone, tends to generate a product which is longer, more positive in outlook, more issue involved, more original, more creative, and more adequate than products of the average group. Finally, the average member will take less time to complete the task; even the slowest man in the group will be competitive in speed with the group.

Although the present research cannot present empirical documentation of this point, it may be speculated that mean differences between the performances of individuals and groups reflect the effects of group process. The problems involved in organizing the efforts of four individuals toward the successful completion of a group project may result in a decrement due to poor coordination. Further, motivation may decrease from the Individual to the Group condition; or, motivation in the sense of arousal may increase beyond the optimum to the degree that it interferes with task performance. Thus, motivation, coordination, or other aspects of group process may have led to the decrement in the product dimensions observed in comparing individual to group performance.

There are many reasons why tasks might be assigned to groups rather than to individuals. The task might be one which could not be solved by any of the individuals alone, perhaps because none possesses a wide enough variety of resources or information. The physical abilities of more than one individual might be demanded, as in moving a heavy object, manipulating a ball-and-spiral apparatus, or the like.

Further, one rationale for participatory decision-making in the literature of social and organizational psychology seems to be

that acceptance of decisions may be greater when several people are implicated in the decision-making process. Indeed, Hoffman (1965) has suggested that group members' acceptance of a decision, and their resulting willingness to help in its implementation, may be of greater significance in some situations than the objective quality of the decision.

In some cases the prestige or authority of a particular committee or group may be necessary to bring about acceptance of solutions or decisions. A course of action which has been decided by an elected council or board may result in greater acceptance than the same course, determined by a single person in authority. The diffusion of responsibility which may occur in group decision-making may also be an important factor in "deciding who shall decide."

But the data of this study seem to show clearly that, for the Hackman task types, individuals are likely to generate better products than groups, at least in terms of speed, Quality of Presentation, Originality, Adequacy, and the like. Thus, while assignment of tasks of these types to groups may be justifiable on tactical grounds (e.g., shared decision-making, diffusion of responsibility), such assignment is clearly not justified on grounds of performance effectiveness.

C. Discussion of the Prediction Models

By and large, group scores on most of the product dimensions are fairly predictable from one or more of the models, at least for some task types. This finding is encouraging in view of the relative lack of success social psychologists have generally had in predicting group measures from characteristics of group members (Mann, 1959; McGrath and Altman, 1966). As pointed out by Davis (in press), greater

success has generally been achieved with the use of individual ability measures, rather than personality variables, as predictor variables. In the present case, the predictor variables may be construed as individual "abilities," and the criteria are in fact the same variables measured on the products of groups rather than those of individuals.

However, the pattern of predictions in the results of this investigation is far from simple; any statement about prediction with a given model must be qualified by task type and by dimension. Analysis for all task types combined indicates that, for the most part, all of the models will predict Action Orientation, Originality, Issue Involvement, and Time, and about equally well. It is interesting that the first three of these variables are the dimensions which characterize the problem-solving, production, and discussion task types, respectively, in the original Hackman research; the present study also found greater differences among the task types on these dimensions, and on Time, than on other dimensions which do not so clearly differentiate the task types. It appears that the task types differ greatly on these dimensions, and these task type differences have the effect of between-group differences in the correlations for combined task types. Thus, they can be predicted very well by any model when all types are combined.

But analysis for only the combined task types would have obscured the more complicated pattern of predictions which appears for the individual task types. In all three cases the archetypical dimensions are predictable for their respective task types, though three of the six significant correlations are negative rather than positive in sign. Further, the three basic models are no longer competitively predictive when data are separated by task type.

There are two ways of looking at predictability according to task type. First, for all three types, about the same number of

dimensions ('five or six') are predictable. And second, in terms of the total number of successful predictions, discussion tasks (thirteen) outdo those of the production (six) and problem-solving (seven) types. Considering only prediction from the three basic models, discussion tasks (nine) are still better than production (two) or problem-solving (four). There seems to be no very sensible a priori explanation why products of the discussion type should be more predictable, but this question warrants further investigation.

Considering prediction by dimension, the same four variables are the only ones which show some generality in prediction, that is, for more than one task type. For these dimensions (Action Orientation, Originality, Issue Involvement, and Time), at least two task types are predictable with some model; for Originality and Issue Involvement, all three types are. Although the Adequacy of three types can be predicted, this can only be done with the multiple regression model. So again, it is the three archetypical dimensions and Time which can be reliably predicted for all task types. Obviously these are the key variables in the present scheme.

Overall, of the three basic models, the minimum model seems most useful. It is clearly superior to the maximum, which produces three successful predictions in comparison with the minimum model's seven. The average model produces five significant correlations within task type. Prediction from the minimum individual can be considered more parsimonious than computation of the group average for use in prediction. So, in those cases where the minimum and average models predict significantly, and about equally well, the minimum model can be viewed as the model of choice.

The multiple R predictions were significant in 10 of the 27 cases within task types. But in several of these there were also

significant predictions from one or more of the zero-order correlations. Since the multiple R not only uses more information than do the minimum or maximum models, but also generates weights which give the maximum linear prediction, it is clearly less parsimonious than any of the other models. Hence, in the three cases where the minimum model and multiple R both predict significantly and about equally well, (Quality of Presentation and Time for discussion tasks, and Action Orientation for problem-solving tasks), the minimum model is again to be considered the preferred model.

D. Implications of Results for Group Process

Overall, the results indicate that certain properties of written group products are relatively predictable from measures of those same properties in the written products of individual members of such groups in response to comparable tasks. Beyond the sheer empirical fact of better than chance predictability, and even beyond the indication that one or another of the combinatorial models seems the model of choice for a particular dimension, the overall pattern of results suggests several general propositions which have to do with the underlying dynamics of group interaction.

First, the relative complexity of the results makes it clear that there is not a single, ubiquitous "group interaction pattern," which holds for all groups on all output dimensions on all task types. Rather, theorists must begin to conceptualize, and small group researchers must find ways to measure, a whole battery of alternative group interaction patterns, whose applicability depends at least on (a) type of task and (b) the output dimension of concern. In just what terms that set of interaction patterns might best be conceptualized remains a question for subsequent study.

Beyond this implication of general complexity, however, there are some further propositions about the nature of interaction patterns which can be derived from study results. One such proposition arises from the relatively general predictive success of the "minimum" or conjunctive model for a range of task types and product dimensions. With a few specific exceptions, the minimum model is at least competitive with, and frequently apparently superior to, the maximum model and the average model. Indeed, in most cases, the minimum model competes favorably with, though it is far more parsimonious than, the multiple correlation model. This general strength of the minimum model for a number of key product dimensions suggests that the group member who has the least "amount" of any given task performance characteristic is the most influential in determining the group's level on that characteristic.

But this influence of "minimum member" is not a simple, isomorphic one. That is, it is not always the case that "the more the least member has of property X the more the group will have of property X." Rather, in certain cases--those with high but negative correlations--the more X this "minimum member" has, the less X there will be in the group product.

So, the rather straightforward notion of the conjunctive model--that the group is "only as good as its poorest member"--is not an adequate interpretation for all cases where the minimum member's score predicts the group score on the same property. When the minimum model predicts, but with a negative correlation, we need some concept other than a conjunctive model to account for it. It is as if, for such a dimension, the group is "only as good on X as its poorest member is poor on X."

Such a relationship suggests the need for a model which considers group homogeneity-heterogeneity on the given attribute. When the lowest member of a group on a given characteristic is very low, then it is more likely that there is a greater range among group members on that characteristic. If so, then the negative correlations for the minimum model may mean that groups whose members are uniformly high on X (so that the lowest man is high) have group products which are low on X; and conversely, groups whose members are heterogeneous on X (with at least the minimum member relatively low) have group products which are high on X.

Consider what this homogeneity model might mean, substantively, for some of the dimensions on which the minimum model predicts in a negative direction.

A group whose minimum member was relatively high on Originality (as for production tasks), would then have been homogeneously high on Originality; this group would have had less original products than another whose members were heterogeneous on that characteristic (i.e., whose minimum member was low on Originality). This might result if the four similar, highly-original members competed with one another with respect to "whose original ideas were best," so that their group products were thereby weakened as to Originality.

Similarly, the negative correlations for the minimum model on Action Orientation (for discussion tasks) may mean that homogeneous groups whose members are all high on Action Orientation cannot easily come to agreement on a single common plan of action, and thus turn out "compromise" products which are relatively low in Action Orientation.

On the other hand, positive correlations for the minimum model may reflect group processes in which inter-member concurrence and mutual support, rather than inter-member conflict, result from the homogeneous-

high condition; inter-member variance or heterogeneity may result in inability of the group to generate "enough" of the characteristic. Thus for the Quality of Presentation dimension (for discussion tasks), for example, groups whose members are uniformly high (which would be reflected in both minimum and average individual scores) have group products which are relatively high in quality, compared to groups whose members are less uniformly high in Quality of Presentation.

Another aspect of the study results which has implications for our understanding of groups has to do with the striking differences in predictability of the models for different individual task types and for all task types combined. It is clear that "group process" is not necessarily the same for groups engaged in different types of task activity--even within a set of three task types which together span only a relatively narrow portion of the total spectrum of group tasks. Not only do the models predict with quite different levels of correlation for different task types, and for all types combined, but in some cases different task types show strong correlations which differ in direction for the same model on the same output dimension. So, not only do task types yield differences in levels of various product dimensions, as Hackman's earlier studies with these tasks have shown (Hackman, 1966) and this study has replicated. Different task types apparently also elicit dramatic differences in the group interaction patterns which lead to various group output dimensions. This is likely in view of the findings of Morris (1965), who reports interaction process differences for these three task types.

A number of further questions about group process and performance are raised but not adequately answered by this study. For example, how general--with respect to tasks, group size, and the group composition,

for example--and how replicable are the substantial mean differences between individual and group products that were found in the present study? And, if those differences are general and replicable, what set of processes within group interaction accounts for them? As another example, just how does group member homogeneity-heterogeneity on various output characteristics operate so as to produce effects which are in a positive direction for some output dimensions but in a negative direction for others? These and a number of other questions are amenable to, and seem to warrant, future research attention. Such research should add appreciably to our understanding of groups and how they operate.

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APPENDIX

Analysis of Variance for
ACTION ORIENTATION--MINIMUM

Source	df	Sum of Squares	Mean Square	F
Task type	2,66	808.78	404.39	1805.80***
Condition Sequence	1,66	.02	.02	.08
Task Type x Condition Sequence	2,66	.42	.21	.94
Task Order	3,198	1.25	.42	1.16
Task Type x Task Order	6,198	1.44	.24	.67
Condition Sequence x Task Order	3,198	11.95	3.98	11.08***
Task Type x Condition Sequence x Task Order	6,198	2.69	.45	1.25

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	1.60
Discussion	2.53
Problem-Solving	5.53

CONDITION SEQUENCE

Individual to Group	3.21
Group to Individual	3.23

TASK ORDER

First	3.30
Second	3.14
Third	3.17
Fourth	3.27

Analysis of Variance for
ACTION ORIENTATION--MAXIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	856.53	428.27	1999.94***
Condition Sequence	1,66	.05	.05	.23
Task Type x Condition Sequence	2,66	.46	.23	1.08
Task Order	3,198	.88	.29	.85
Task Type x Task Order	6,198	1.63	.27	.79
Condition Sequence x Task Order	3,198	10.89	3.63	10.54***
Task Type x Condition Sequence x Task Order	6,198	1.63	.27	.79

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	1.88
Discussion	2.99
Problem-Solving	5.97

CONDITION SEQUENCE

Individual to Group	3.60
Group to Individual	3.63

TASK ORDER

First	3.66
Second	3.56
Third	3.56
Fourth	3.68

Analysis of Variance for
ACTION ORIENTATION--AVERAGE

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	851.02	425.51	2441.77***
Condition Sequence	1,66	.03	.03	.18
Task Type x Condition Sequence	2,66	.30	.15	.86
Task Order	3,198	1.95	.32	1.01
Task Type x Task Order	6,198	1.11	.18	.59
Condition Sequence x Task Order	3,198	.34	.11	.36
Task Type x Condition Sequence x Task Order	6,198	1.32	.22	.70

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	1.72
Discussion	2.75
Problem-Solving	5.77

CONDITION SEQUENCE

Individual to Group	3.40
Group to Individual	3.42

TASK ORDER

First	3.48
Second	3.35
Third	3.37
Fourth	3.46

Analysis of Variance for
LENGTH--MINIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	43.40	21.70	9.71***
Condition Sequence	1,66	.79	.79	.35
Task Type x Condition Sequence	2,66	3.55	1.77	.79
Task Order	3,198	1.34	.45	.27
Task Type x Task Order	6,198	9.87	1.65	.98
Condition Sequences x Task Order	3,198	12.03	4.01	2.40
Task Type x Condition Sequence x Task Order	6,198	23.29	3.86	2.32*

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	3.35
Discussion	3.20
Problem-Solving	2.46

CONDITION SEQUENCE

Individual to Group	3.06
Group to Individual	2.95

TASK ORDER

First	3.06
Second	3.07
Third	2.89
Fourth	3.00

Analysis of Variance for
LENGTH--MAXIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	24.93	12.46	5.99**
Condition Sequence	1,66	4.07	4.07	1.95
Task Type x Condition Sequence	2,66	4.49	2.25	1.08
Task Order	3,198	5.32	1.77	1.07
Task Type x Task Order	6,198	4.01	.67	.40
Condition Sequence x Task Order	3,198	444.15	148.05	89.47***
Task Type x Condition Sequence x Task Order	6,198	34.94	5.82	3.52**

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	4.32
Discussion	4.25
Problem-Solving	3.66

CONDITION SEQUENCE

Individual to Group	4.20
Group to Individual	3.96

TASK ORDER

First	4.13
Second	4.27
Third	3.93
Fourth	3.97

Analysis of Variance for
LENGTH--AVERAGE

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	32.98	16.49	7.91***
Condition Sequence	1,66	2.07	2.07	.99
Task Type x Condition Sequence	2,66	3.69	1.85	.89
Task Order	3,198	2.55	.85	.54
Task Type x Task Order	6,198	7.68	1.28	.82
Condition Sequence x Task Order	3,198	147.75	49.25	31.47***
Task Type x Condition Sequence x Task Order	6,198	28.72	4.79	3.06**

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	3.83
Discussion	3.74
Problem-Solving	3.07

CONDITION SEQUENCE

Individual to Group	3.63
Group to Individual	3.46

TASK ORDER

First	3.61
Second	3.67
Third	3.45
Fourth	3.47

Analysis of Variance for
ORIGINALITY--MINIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	147.49	73.74	177.15***
Condition Sequence	1,66	1.66	1.66	4.00*
Task Type x Condition Sequence	2,66	1.13	.56	1.35
Task Order	3,198	1.90	.63	.67
Task Type x Task Order	6,198	1.65	.27	.29
Condition Sequence x Task Order	3,198	7.48	2.49	2.63*
Task Type x Condition Sequence x Task Order	6,198	5.38	.90	.95

* $p < .05$

** $p < .01$

*** $p < .001$

Marginal Means

TASK TYPE

Production	3.48
Discussion	2.05
Problem-Solving	1.88

CONDITION SEQUENCE

Individual to Group	2.54
Group to Individual	2.39

TASK ORDER

First	2.46
Second	2.36
Third	2.47
Fourth	2.59

Analysis of Variance for
ORIGINALITY--MAXIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	200.85	100.43	106.69***
Condition Sequence	1,66	5.84	5.84	6.20*
Task Type x Condition Sequence	2,66	3.26	1.63	1.73
Task Order	3,198	1.37	4.56	.36
Task Type x Task Order	6,198	4.78	.80	.63
Condition Sequence x Task Order	3,198	102.66	34.22	27.16***
Task Type x Condition Sequence x Task Order	6,198	6.35	1.06	.84

* $p < .05$

** $p < .01$

*** $p < .001$

Marginal Means

TASK TYPE

Production	4.38
Discussion	2.83
Problem-Solving	2.45

CONDITION SEQUENCE

Individual to Group	3.36
Group to Individual	3.08

TASK ORDER

First	3.22
Second	3.24
Third	3.12
Fourth	3.31

Analysis of Variance for
ORIGINALITY--AVERAGE

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	176.08	88.04	180.33***
Condition Sequence	1,66	2.49	2.49	5.09*
Task Type x Condition Sequence	2,66	1.50	.75	1.54
Task Order	3,198	1.29	.43	.42
Task Type x Task Order	6,198	2.37	.39	.38
Condition Sequence x Task Order	3,198	9.64	3.21	3.12*
Task Type x Condition Sequence x Task Order	6,198	2.68	.45	.43

* $p < .05$

** $p < .01$

*** $p < .001$

Marginal Means

TASK TYPE

Production	3.91
Discussion	2.37
Problem-Solving	2.15

CONDITION SEQUENCE

Individual to Group	2.90
Group to Individual	2.71

TASK ORDER

First	2.79
Second	2.74
Third	2.78
Fourth	2.92

Analysis of Variance for
OUTLOOK--MINIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	19.50	9.75	22.39***
Condition Sequence	1,66	2.49	2.49	5.72*
Task Type x Condition Sequence	2,66	.17	.08	.19
Task Order	3,198	.22	.07	.16
Task Type x Task Order	6,198	.91	.15	.33
Condition Sequence x Task Order	3,198	28.16	9.39	20.22***
Task Type x Condition Sequence x Task Order	6,198	6.69	1.11	2.40*

* $p < .05$

** $p < .01$

*** $p < .001$

Marginal Means

TASK TYPE

Production	3.50
Discussion	3.87
Problem-Solving	4.13

CONDITION SEQUENCE

Individual to Group	3.74
Group to Individual	3.93

TASK ORDER

First	3.87
Second	3.81
Third	3.85
Fourth	3.80

Analysis of Variance for
OUTLOOK--MAXIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	21.22	10.61	34.69***
Condition Sequence	1,66	.50	.50	1.63
Task Type x Condition Sequence	2,66	.39	.20	.64
Task Order	3,198	1.29	.43	1.28
Task Type x Task Order	6,198	.89	.15	.44
Condition Sequence x Task Order	3,198	32.81	10.93	32.52***
Task Type x Condition Sequence x Task Order	6,198	.94	.16	.47

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	4.12
Discussion	4.77
Problem-Solving	4.57

CONDITION SEQUENCE

Individual to Group	4.44
Group to Individual	4.52

TASK ORDER

First	4.51
Second	4.58
Third	4.46
Fourth	4.39

Analysis of Variance for
OUTLOOK--AVERAGE

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	21.08	10.53	39.76***
Condition Sequence	1,66	.75	.75	2.84
Task Type x Condition Sequence	2,66	.25	.13	.48
Task Order	3,198	.89	.30	1.04
Task Type x Task Order	6,198	1.15	.19	.68
Condition Sequence x Task Order	3,198	.24	.08	.28
Task Type x Condition Sequence x Task Order	6,198	.74	.12	.43

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	3.79
Discussion	4.36
Problem-Solving	4.36

CONDITION SEQUENCE

Individual to Group	4.12
Group to Individual	4.22

TASK ORDER

First	4.22
Second	4.23
Third	4.16
Fourth	4.09

Analysis of Variance for
QUALITY OF PRESENTATION--MINIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	34.85	17.42	12.10***
Condition Sequence	1,66	.69	.69	.48
Task Type x Condition Sequence	2,66	.62	.31	.22
Task Order	3,198	.20	.68	.82
Task Type x Task Order	6,198	4.85	.81	.97
Condition Sequence x Task Order	3,198	5.04	1.68	2.02
Task Type x Condition Sequence x Task Order	6,198	7.08	1.18	1.42

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	3.30
Discussion	4.15
Problem-Solving	3.74

CONDITION SEQUENCE

Individual to Group	3.68
Group to Individual	3.78

TASK ORDER

First	3.73
Second	3.86
Third	3.65
Fourth	3.67

Analysis of Variance for
QUALITY OF PRESENTATION--MAXIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	34.82	17.41	17.44***
Condition Sequence	1,66	.26	.26	.26
Task Type x Condition Sequence	2,66	.15	.07	.07
Task Order	3,198	3.68	1.23	1.34
Task Type x Task Order	6,198	3.54	.59	.65
Condition Sequence x Task Order	3,198	163.03	54.34	59.52***
Task Type x Condition Sequence x Task Order	6,198	7.69	1.28	1.40

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	4.00
Discussion	4.85
Problem-Solving	4.48

CONDITION SEQUENCE

Individual to Group	4.42
Group to Individual	4.48

TASK ORDER

First	4.48
Second	4.60
Third	4.28
Fourth	4.43

Analysis of Variance for
QUALITY OF PRESENTATION--AVERAGE

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	33.22	16.61	15.13***
Condition Sequence	1,66	.52	.52	.48
Task Type x Condition Sequence	2,66	.10	.05	.04
Task Order	3,198	3.00	1.00	1.21
Task Type x Task Order	6,198	3.71	.62	.75
Condition Sequence x Task Order	3,198	47.37	15.79	19.06***
Task Type x Condition Sequence x Task Order	6,198	6.21	1.03	1.25

* $p < .05$

** $p < .01$

*** $p < .001$

Marginal Means

TASK TYPE

Production	3.67
Discussion	4.50
Problem-Solving	4.11

CONDITION SEQUENCE

Individual to Group	4.05
Group to Individual	4.14

TASK ORDER

First	4.09
Second	4.25
Third	3.96
Fourth	4.07

Analysis of Variance for
ISSUE INVOLVEMENT--MINIMA

Source	df	Sum of Squares	Mean Square	F
Task Type	2,56	492.46	246.23	633.61***
Condition Sequence	1,56	.12	.10	.26
Task Type x Condition Sequence	2,56	.38	.49	1.24
Task Order	3,198	.27	.09	.13
Task Type x Task Order	6,198	2.44	.41	.58
Condition Sequence x Task Order	3,198	1.69	.56	.90
Task Type x Condition Sequence x Task Order	6,198	3.40	.57	.81

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	1.59
Discussion	4.71
Problem-Solving	2.46

CONDITION SEQUENCE

Individual to Group	2.90
Group to Individual	2.93

TASK ORDER

First	2.93
Second	2.95
Third	2.91
Fourth	2.87

Analysis of Variance for
ISSUE INVOLVEMENT--MAXIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,56	545.73	272.86	670.54***
Condition Sequence	1,56	.05	.05	.11
Task Type x Condition Sequence	2,56	.25	.13	.32
Task Order	3,198	1.05	.35	.47
Task Type x Task Order	6,198	1.10	.18	.25
Condition Sequence x Task Order	3,198	113.86	37.95	51.08***
Task Type x Condition Sequence x Task Order	6,198	14.51	2.42	3.26**

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	1.98
Discussion	5.30
Problem-Solving	3.12

CONDITION SEQUENCE

Individual to Group	3.48
Group to Individual	3.46

TASK ORDER

First	3.51
Second	3.54
Third	3.39
Fourth	3.43

Analysis of Variance for
ISSUE INVOLVEMENT--AVERAGE

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	528.30	264.15	780.87***
Condition Sequence	1,66	.05	.05	.15
Task Type x Condition Sequence	2,66	.40	.20	.60
Task Order	3,198	.31	.10	.15
Task Type x Task Order	6,198	1.40	.23	.34
Condition Sequence x Task Order	3,198	33.85	11.29	16.31***
Task Type x Condition Sequence x Task Order	6,198	8.95	1.49	2.16*

* $p < .05$

** $p < .01$

*** $p < .001$

Marginal Means

TASK TYPE

Production	1.76
Discussion	5.01
Problem-Solving	2.78

CONDITION SEQUENCE

Individual to Group	3.17
Group to Individual	3.20

TASK ORDER

First	3.20
Second	3.23
Third	3.15
Fourth	3.15

Analysis of Variance for
ADEQUACY--MINIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	11.05	5.52	3.78*
Condition Sequence	1,66	.03	.03	.02
Task Type x Condition Sequence	2,66	1.00	.50	.34
Task Order	3,198	3.68	1.23	.82
Task Type x Task Order	6,198	4.59	.77	.51
Condition Sequence x Task Order	3,198	33.46	11.15	7.47***
Task Type x Condition Sequence x Task Order	6,198	15.22	2.54	1.70

* $p < .05$

** $p < .01$

*** $p < .001$

Marginal Means

TASK TYPE

Production	3.91
Discussion	3.49
Problem-Solving	3.89

CONDITION SEQUENCE

Individual to Group	3.77
Group to Individual	3.75

TASK ORDER

First	3.59
Second	3.81
Third	3.75
Fourth	3.90

Analysis of Variance for
ADEQUACY--MAXIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	15.09	6.52	6.19**
Condition Sequence	1,66	.19	.19	.18
Task Type x Condition Sequence	2,66	.84	.42	.40
Task Order	3,198	2.97	.99	.81
Task Type x Task Order	6,198	4.62	.77	.63
Condition Sequence x Task Order	3,198	155.42	51.81	42.61***
Task Type x Condition Sequence x Task Order	6,198	11.89	1.98	1.63

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	5.06
Discussion	4.55
Problem-Solving	4.88

CONDITION SEQUENCE

Individual to Group	4.86
Group to Individual	4.81

TASK ORDER

First	4.69
Second	4.83
Third	4.79
Fourth	4.97

Analysis of Variance for
ADEQUACY--AVERAGE

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	12.17	6.59	6.27**
Condition Sequence	1,66	4.37	.41	.39
Task Type x Condition Sequence	2,66	.83	.42	.40
Task Order	3,198	1.85	.52	.51
Task Type x Task Order	6,198	4.52	.75	.62
Condition Sequence x Task Order	3,198	15.92	5.01	4.13**
Task Type x Condition Sequence x Task Order	6,198	12.05	2.01	1.66

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	4.53
Discussion	4.03
Problem-Solving	4.39

CONDITION SEQUENCE

Individual to Group	4.35
Group to Individual	4.28

TASK ORDER

First	4.21
Second	4.36
Third	4.28
Fourth	4.42

Analysis of Variance for
CREATIVITY--MINIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	32.68	16.34	11.11***
Condition Sequence	1,66	1.44	1.44	.98
Task Type x Condition Sequence	2,66	.31	.16	.11
Task Order	3,198	2.63	.88	.83
Task Type x Task Order	6,198	11.19	18.65	1.76
Condition Sequence x Task Order	3,198	10.54	3.51	3.31*
Task Type x Condition Sequence x Task Order	6,198	42.60	7.10	6.69***

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	2.64
Discussion	2.69
Problem-Solving	1.95

CONDITION SEQUENCE

Individual to Group	2.50
Group to Individual	2.36

TASK ORDER

First	2.37
Second	2.50
Third	2.30
Fourth	2.54

Analysis of Variance for
CREATIVITY--MAXIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	47.36	23.68	14.61***
Condition Sequence	1,66	3.63	3.63	2.24
Task Type x Condition Sequence	2,66	3.16	1.58	.98
Task Order	3,198	7.02	2.34	1.86
Task Type x Task Order	6,198	4.07	.68	.54
Condition Sequence x Task Order	3,198	308.25	102.75	81.75***
Task Type x Condition Sequence x Task Order	6,198	15.33	2.56	2.03

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	4.11
Discussion	3.69
Problem-Solving	3.13

CONDITION SEQUENCE

Individual to Group	3.76
Group to Individual	3.53

TASK ORDER

First	3.66
Second	3.73
Third	3.39
Fourth	3.80

Analysis of Variance for
CREATIVITY--AVERAGE

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	39.99	20.00	14.55***
Condition Sequence	1,66	1.78	1.78	1.30
Task Type x Condition Sequence	2,66	1.31	.66	.48
Task Order	3,198	4.09	1.36	1.24
Task Type x Task Order	6,198	6.67	1.11	1.01
Condition Sequence x Task Order	3,198	48.60	16.20	14.78***
Task Type x Condition Sequence x Task Order	6,198	26.56	4.43	4.04***

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	3.36
Discussion	3.20
Problem-Solving	2.50

CONDITION SEQUENCE

Individual to Group	3.10
Group to Individual	2.94

TASK ORDER

First	2.99
Second	3.09
Third	2.84
Fourth	3.16

Analysis of Variance for
TIME--MINIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	340.61	170.30	9.80***
Condition Sequence	1,66	.68	.68	.04
Task Type x Condition Sequence	2,66	26.37	13.18	.76
Task Order	3,198	62.26	20.75	2.48
Task Type x Task Order	6,198	12.59	2.10	.25
Condition Sequence x Task Order	3,198	1090.37	363.46	43.35***
Task Type x Condition Sequence x Task Order	6,198	11.95	1.99	.24

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	11.51
Discussion	11.15
Problem-Solving	9.04

CONDITION SEQUENCE

Individual to Group	10.52
Group to Individual	10.61

TASK ORDER

First	11.31
Second	10.61
Third	10.24
Fourth	10.11

Analysis of Variance for
TIME--MAXIMUM

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	356.94	178.47	14.06***
Condition Sequence	1,66	.31	.31	.02
Task Type x Condition Sequence	2,66	25.17	12.58	.99
Task Order	3,198	56.59	18.86	2.68*
Task Type x Task Order	6,198	8.64	1.44	.20
Condition Sequence x Task Order	3,198	5.77	1.26	.18
Task Type x Condition Sequence x Task Order	6,198	9.01	1.50	.21

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	13.52
Discussion	13.11
Problem-Solving	10.98

CONDITION SEQUENCE

Individual to Group	12.50
Group to Individual	12.57

TASK ORDER

First	13.19
Second	12.70
Third	12.10
Fourth	12.16

Analysis of Variance for
TIME--AVERAGE

Source	df	Sum of Squares	Mean Square	F
Task Type	2,66	356.03	178.01	12.63***
Condition Sequence	1,66	1.09	1.09	.08
Task Type x Condition Sequence	2,66	34.54	17.27	1.23
Task Order	3,198	54.43	18.14	2.57
Task Type x Task Order	6,198	12.63	2.11	.30
Condition Sequence x Task Order	3,198	247.53	82.51	11.69***
Task Type x Condition Sequence x Task Order	6,198	6.96	1.16	.16

*p < .05

**p < .01

***p < .001

Marginal Means

TASK TYPE

Production	12.52
Discussion	12.22
Problem-Solving	10.02

CONDITION SEQUENCE

Individual to Group	11.53
Group to Individual	11.65

TASK ORDER

First	12.27
Second	11.67
Third	11.21
Fourth	11.20

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13. ABSTRACT This report is a by-product of a major research program on the social and psychological aspects of stress. Characteristics of the performance of individuals were used to predict the same dimensions of the products they wrote as 4-man groups. The minimum, maximum, and average individuals' scores were correlated with the group's score, for 8 rated dimensions of written products and for time to solution. For all groups in the study, 3 dimensions and time to solution were highly predictable using more than 1 of the basic models; these 3 dimensions were those which best differentiated the 3 types of tasks in the sample. When the task types were separated, predictability of group scores with the 3 models varied with task type and dimensions; the minimum individual's score was generally a better predictor of group scores than was the maximum or average, and this model compared favorably with prediction using multiple linear regression. The concepts pattern of positive and negative correlations between group scores and those of the minimum individual.			

Severely Corroded Areas

Factors	Group A		Group B		Group C	
	Role	Age	Role	Age	Role	Age
Group performance						
Task differences						
Maximum model						
Individual performance						
Group output						
Motivation						
Time to solution						

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